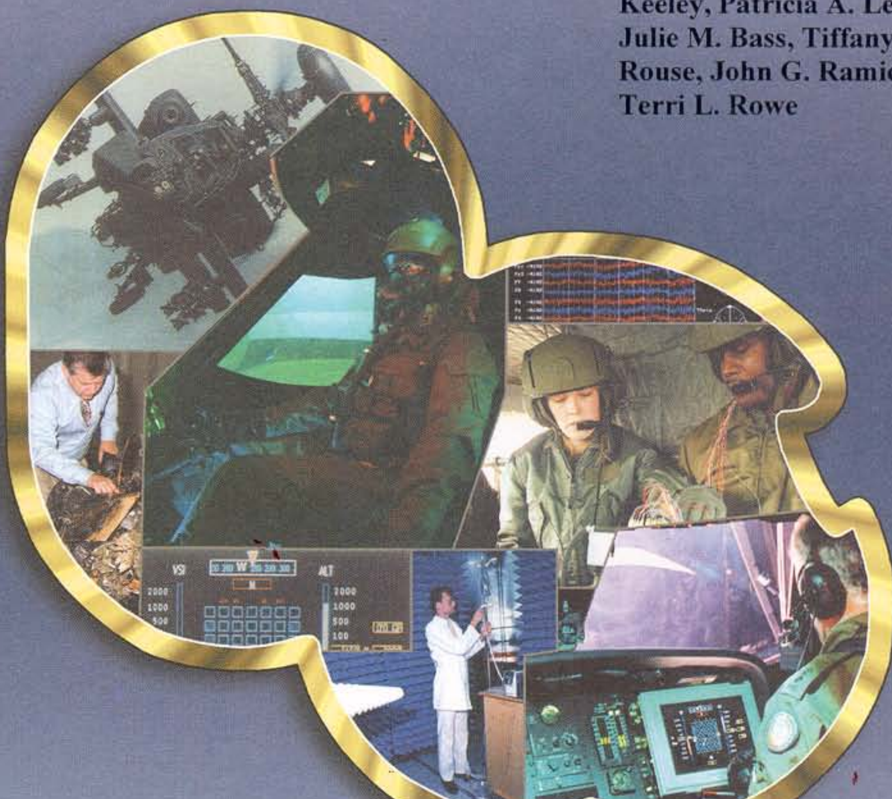
USAARL Report No. 2007-07

A Novel Approach in Facilitating Aviation Emergency Procedure Learning and Recall through an Intuitive Pictorial System

By Arthur Estrada, Jennifer A. Keeley, Patricia A. LeDuc, Julie M. Bass, Tiffany N. Rouse, John G. Ramiccio, and Terri L. Rowe



Aircrew Health and Performance Division

January 2007

USAARL

U.S. Army Aeromedical Research Laboratory

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
JAN 2007	**Final**	**00-00-2007 to 00-00-2007**

4. TITLE AND SUBTITLE
A Novel Approach in Facilitating Aviation Emergency Procedure Learning and Recall through an Intuitive Pictorial System

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER
622787

6. AUTHOR(S)
Arthur Estrada; Jennifer Keeley; Patricia LeDuc; Julie Bass; Tiffany Rouse

5d. PROJECT NUMBER
878

5e. TASK NUMBER
O

5f. WORK UNIT NUMBER
DA0G0165

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Aeromedical Research Laboratory,P.O. Box 620577,Fort Rucker,AL,36362-0577

8. PERFORMING ORGANIZATION REPORT NUMBER
2007-07

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Medical Research and Materiel Command, 504 Scott Street, Fort Detrick, MD, 21702-5012

10. SPONSOR/MONITOR'S ACRONYM(S)
USAMRMC

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT
Research has demonstrated that providing students with memorization techniques improved their ability to recall information. This study employed a pretest-posttest, control group design to test the effectiveness of a novel mnemonic strategy: the Intuitive Pictorial System (IPS). Descriptive and inferential statistics, along with correlation, were used to assess the study data, which determined statistically significant differences between the IPS and traditional training methods. Although the study?s findings did not show the IPS as producing performance gains superior to that of the traditional method, user assessments and symbol recognition performance demonstrated the utility and merit of the system as an augmentation. The manner in which the symbols were able to facilitate the recall of uncommon, unfamiliar terms and phrases in a na?ve population to a level comparable to that of highly-experienced pilots in just one week highlighted the IPS?s capacity to aid in the encoding of information into long-term memory. This information could lead to important innovations to current U.S. Army teaching methods and aviation safety.

15. SUBJECT TERMS
Memory, cognition, memorization strategies, mnemonics, emergency procedures training, pictorials

<table>
<tr><td colspan="3">16. SECURITY CLASSIFICATION OF:</td><td rowspan="2">17. LIMITATION OF ABSTRACT</td><td rowspan="2">18. NUMBER OF PAGES
126</td><td rowspan="2">19a. NAME OF RESPONSIBLE PERSON</td></tr>
<tr><td>a. REPORT
unclassified</td><td>b. ABSTRACT
unclassified</td><td>c. THIS PAGE
unclassified</td></tr>
</table>

Notice

Qualified requesters

Qualified requesters may obtain copies from the Defense Technical Information Center (DTIC), 8725 John J Kingman Road, Suite 0944, Fort Belvoir, Virginia 22060-6218. Orders will be expedited if placed through the librarian or other person designated to request documents from DTIC.

Change of address

Organizations receiving reports from the U.S. Army Aeromedical Research Laboratory on automatic mailing lists should confirm correct address when corresponding about Laboratory reports.

Disposition

Destroy this document when it is no longer needed. Do not return it to the originator.

Disclaimer

Acknowledgements

The authors would like to express their sincere gratitude to the following people for their contributions to this project. This was a complex effort requiring much coordination and teamwork. Without the assistance of the following people, this project would not have been such a success.

- Dr. Robert M. Wildzunas, Director, Warfighter Performance and Health Division, and Dr. John S. Crowley, USAARL Science Program Director for their invaluable advice, technical assistance, and support for this project.
- Diana Hemphill (Technical Information Officer) and Sharon Fales (Librarian) for their invaluable assistance with literature searches and reviews.
- Lisa Dueringer for her keen editing expertise.
- Elizabeth Stokes, WPHD's secretary, for help with all matters administrative.
- Lynda and Amanda Estrada for their steadfast support and remarkable patience throughout this effort.

Table of contents

Table of contents (continued)

Page

Table of contents (continued)

Table of contents (continued)

Page

List of figures

List of tables

Table of contents (continued)

Page

Introduction

The intent of this research was to examine the utility and merit of a novel system of intuitive symbols (a mnemonic strategy) in conjunction with the training of emergency procedures to U.S. Army aviation students in order to facilitate the accurate recall of those procedures. Ever since earth-bound man decided to take to the skies in flying machines, he has had to deal with emergency situations created by the occasional malfunction or failure of aircraft components. The steps taken to correct, or at least ameliorate, the condition must, by necessity, be performed in an established manner and/or sequence. To this end, all student pilots must learn (memorize) and practice emergency procedures (ordered steps) established for specific emergency events for the particular model of aircraft in which they are being trained. As an example, currently, pilots of the Army's UH-60 Black Hawk helicopter are required to learn procedural steps for up to 56 emergency situations (Headquarters, Department of the Army, 2003).

Background

The first step in the U.S. Army's current practice of teaching aviation emergency procedures is to require student pilots to learn the textual procedures through rote memorization. No standardized or formal guidance or techniques are provided as best practices in which to learn them. Therefore, conventional training consists of the requirement for student pilots to learn these steps from textual lists provided in the model-specific operator's manuals. The U.S. Army is particularly demanding of their student and graduate pilots in that it requires the memorization of an extensive number of emergency procedures (many more than the other military services require), each of which usually contains multiple, purposefully-ordered steps. The satisfactory demonstration of emergency procedures recall and performance is a requirement for the completion of flight school and the annual evaluations of graduate pilots (Headquarters, Department of the Army, 1996).

The recall of the multitude of emergency procedures required is a daunting effort. Actual aircraft emergencies are infrequent and some are quite rare. Hence, without active recurring maintenance (practice) of the conventionally-learned textual procedures, the ability of recall begins to decay significantly over a relatively short period of time which results in the inability to respond accurately and instantly in the event of an actual emergency, the consequences of which can be catastrophic. This premise is supported by the results of an anonymous survey (Estrada and Dumond, 2006) of Army aviators (n = 194) conducted by the U.S. Army Aeromedical Research Laboratory (USAARL) that indicate that 16% of the respondents report reciting or practicing their emergency procedures daily, while 48% convey that they practice at least weekly. This reported need to practice so frequently even after many years of such practice is indicative of a memory strategy that appears to be ineffective at transforming these procedural steps to reliably retrievable memory. Interestingly, 8% of the respondents are not satisfied with their current memorization methods while 66% indicate an interest in learning new memorization strategies to help retain their emergency procedures.

The Instructor Pilot Handbook (U.S. Army Aviation Center, 2000) provides three theories that account for the forgetting [of emergency procedures]: disuse, interference, and

repression. *Disuse* refers to information that is not often used. This may explain the difficulty in remembering some emergency procedures that are the least frequently practiced. *Interference* describes what may happen when similar information interferes with the memory of information previously learned. New events or experiences can displace previous ones. Many "seasoned" aviators experience interference when the steps of emergency procedures are changed over time. *Repression* is said to occur when unpleasant or anxiety-producing material is unintentionally suppressed by an individual. Perhaps not common, but repression of information is certainly possible when learning is complicated or difficult, as is certainly possible and probable in flight training.

There are a number of theories suggesting the mechanisms in which the brain transforms a perception (objects, text) to meaningful perception (concepts) to a retrievable memory. These will be explored in further detail later. Regardless of the theoretical mechanisms, the purpose of any learning is to transfer new information from working or short-term memory (a temporary store) to long-term memory, memory that has no capacity limits and holds information from minutes to an entire lifetime (Reed, 2004). Previous research and experience has demonstrated that providing students with instructions on the use of memorization techniques (mnemonic strategies) has resulted in improvements in their ability to recall learned information (Carney and Levin, 2003; Kleinheksel and Summy, 2003; Hwang and Levin, 2002; Carney and Levin, 2002; Cox, 2001). Mnemonic strategies are systematic procedures for enhancing memory (Mastropieri and Scruggs, 1998) and are used to facilitate the acquisition of factual information because they assist in the memory encoding process, either by providing familiar connections or by creating new connections between to-be-remembered information and the learner's prior knowledge (Levin and Levin, 1990).

An intuitive pictorial system

With the above said, this research sought to examine the utility and merit of a novel system of intuitive pictures (the Intuitive Pictorial System or IPS) taught as a mnemonic strategy to facilitate learning and accurate recall of complex emergency procedures. In addition, analyses were conducted to determine the effectiveness of this novel mnemonic strategy with respect to the aviators' levels of flight experience, their learning style preferences, and their overall subjective assessments of the system.

The pictures that comprise the IPS are characterized as *intuitive* as they are formed with symbols representing aircraft parts and systems and are presumed easily and immediately recognizable to pilots. Thus, they require no cognitive effort in determining their meanings. For example, the capital T is easily visualized as a helicopter rotor system (the top of the T represents the rotor blades). Any picture with a T would necessarily, and intuitively, involve the rotor system. The intuitive pictorial system (its symbols and their meanings) is available in Appendix A.

The IPS is novel in that 1) it is the creation of the researcher, and 2) to this day, there has never been an attempt to introduce any structured, formal mnemonic strategy system to the learning of Army aviation emergency procedures. This novel approach to teaching aviation emergency procedures may be an important innovation to current Army teaching techniques and

a notable contribution to aviation training and safety with possible applications to the other military services and the civil aviation community.

Research problem

A commonly-expressed problem by U.S. Army pilots is that without recurrent practice and recitation, they tend to lose their ability to retain and recall important aircraft emergency procedures over a relatively short period of time. Evidence of this problem is provided by the results of a USAARL emergency procedures survey (Estrada and Dumond, 2006) from which it was discovered that 27.8% of the respondents disagreed that learning new emergency procedures was easy. In addition, 68% reported that they must study or practice reciting their procedures often, with 77.9% conveying that they must practice more often than once every two weeks in order to maintain proficiency. No known efforts have been made by those responsible for Army aviation training to explore and make use of innovative training or mnemonic techniques in order to improve the current state.

U.S. Army pilots are required to learn a multitude of emergency procedures containing multiple textual steps and are then required to recall them verbatim in preparation for simulated or actual emergency situations. The syntax of the steps tends to be structurally cumbersome and may contribute to the difficulty in memorizing them. The maintenance of these textual procedures, even after they are "learned," requires hours of study "refreshing one's memory" in order to maintain proficiency, and yet experience shows that such efforts do not assure accuracy and timeliness of recall. In a reasonable comparison, a study of the memory strategies of professional actors by Noice (1992) discovered that there was unanimous agreement among the actors that they do not memorize their lines in a rote-type fashion (as the Army requires). Even if the Army student pilot progresses beyond rote memorization (the lowest level of learning) to the higher levels of *understanding*, *application*, and *correlation* (U.S. Army Aviation Center, 2000), the form (the textual format) in which the emergency procedures are presented, combined with the disuse or infrequency in performing the procedures once the student graduates from flight school, contributes to the general tendency to forget the specific procedures. It is common knowledge among graduate pilots that the memory of these steps is quite perishable and requires a considerable amount of time rehearsing even after years of experience and practice. The consequences of forgetting them can range from an unsatisfactory grade during flight evaluations to the more serious inability to respond to and perform correctly during an actual emergency situation (Cumbie, 2003).

According to Bellezza (1992), memory experts, called mnemonists, learn to create mental pictures that endure in the mental space. Thus, the IPS depicts each emergency situation and its procedural steps in a single pictorial form. Bellezza writes that it appears that experiencing and manipulating vivid visual images is the manner by which mnemonists memorize information. In an article regarding visual puns as illustrations, Abed (1994) notes, "Initially, capturing the attention of the learner is a crucial step that interactive illustrations are capable of achieving." The expectation was that the IPS was capable of serving that purpose and would be helpful in improving a pilot's ability to retain emergency procedures over time.

Research questions

The specific research questions that directed this study were:

1. Will the employment of the IPS demonstrate improved retention and recall of emergency procedures over that of the traditional teaching method in the overall sample population?
2. Is there a difference in the recall performance between those taught using the traditional method and those taught using the IPS method with respect to experience levels (highly-experienced instructor pilots, minimally-experienced student pilots, and naïve students)?
3. Is there a difference in the recall performance between those taught using the traditional method and those taught using the IPS method with respect to individual learning style preferences (visual, aural, read/write, and kinesthetic)?
4. Does recall performance have any correlation to the manner in which the IPS is assessed?
5. Do individual learning style preferences have an effect on the aviators' subjective assessment of the IPS (pictorial mnemonics) as an aid in memorizing textual emergency procedures?
6. Do experience levels have an effect on the aviators' subjective assessment of the IPS (pictorial mnemonics) as an aid in memorizing textual emergency procedures?
7. Is the IPS assessed positively by the majority of those in the treatment groups as a useful pictorial mnemonic for remembering aviation emergency procedures?
8. After instruction, are the symbols that make up the IPS easily recognized (intuitive) and thus, remembered (have memorable qualities)?
9. Is there an association between committed study time from Day 1 to Day 7 and posttest performances?

Literature review and theoretical background

Too many times educators tell students *what* to learn yet fail to teach students *how* to learn. Ashman and Conway (1997) describe a paradigm shift in learning since the mid-1980s from one in which the "emphasis is on content and acquiring a body of right knowledge" to one in which the "emphasis is on learning how to learn." Knowing "how to learn" involves the learning of strategies. Strategies refer to the many methods in which we take in (encode), store, and retrieve (decode) information. Unfortunately, strategies used for enhancing learning are not an innate student ability. "Teachers must build into the learning context retrieval cues that will likely be present when the students need to recall the concept" (Squire and Kandel, quoted by King-Friedrichs, 2001).

Moley, et al. (quoted by Cox, 2001) reported that strategies are seldom taught in the classroom. Results of a study by Cox indicated that many young elementary school children, without training, do not use an organized sorting strategy to aid memorization. In his experiment, Cox found that untrained children used sorting strategies that were "haphazard at best, passive at worst, and they produced sorts that were reliably judged as random…" Predictably, Moley and Hart (1992) write that students of those teachers who often suggested

strategies showed better maintenance and more deliberate use of the trained strategies than did children whose teachers rarely made strategy suggestions.

Studies into the effectiveness of mnemonic strategies indicate that considerable success is achieved in the retention and recall of the information. How much is remembered depends on what was already known about what is being remembered (Kuhn 2000). Mastropieri and Scruggs (1998) write that the particular task in developing mnemonic strategies is to find a way to relate new information to information students already have locked in long-term memory. They continue, "If we can make a firm enough connection, the memory will last a very long time." In Cox's (2001) study, his findings confirmed the many common findings of earlier work: that mnemonic strategies are not difficult to train to students and that once learned, produce measurable improvements in their recall performance over time. Cox observes that when left to their own devices, children will construct their own haphazard strategies. These variations, he notes, in the effectiveness of these self-constructed strategies undoubtedly contribute to the wide individual differences in their development. In several experiments, Levin and his associates (Carney and Levin, 2003; Hwang and Levin, 2002; Carney and Levin, 2002) have demonstrated the utility of employing pictorially-based mnemonic strategies. In each experiment, results have indicated the statistically significant superior performance of those employing a taught strategy over that of an untrained control group.

Theoretical framework

The suggestion of employing a novel training technique or teaching approach over that of a traditional method requires evidence that the novel system will result in improved knowledge retention or recall performance. In this study's specific case, the IPS must demonstrate an improvement in the users' memory for the information. The novelty of the approach in facilitating aviation emergency procedure learning and recall through an intuitive pictorial system unavoidably *begins* with a change from the traditional method in the presentation of the information, specifically, from a textual format to that of a pictorial representation of the information. This alteration in form presumably influences visual perception, which in turn potentially affects the visual and conceptual cognition of the information (the learning). The affected cognitive process may change the manner and speed in which the knowledge is retained in the memory and may ultimately have an effect on the ability to recall the information when needed or desired. In other words, it is impossible to study "any type of memory processing in isolation from the other aspects of the developing cognitive system" (Schneider and Bjorklund, 1998, p. 492). Kuhn (2000) puts it this way:

> Although memory has long been regarded as a central and well-defined topic within the field of cognitive development, developments in and related to the study of memory increasingly suggest that the study of memory needs to be situated in a number of broader conceptual and research contexts.

That being said, the following is an examination and review of the theoretical bases for suggesting that a pictorially-based, mnemonic strategy might be effective and covers a wide range of interrelated domains.

Learning

Learning can be described as the gaining of knowledge, understanding, or skill (Webster's Ninth New Collegiate Dictionary, 1985) with an outcome of a change in behavior [overt or subtle] as a result of the experience (U.S. Army Aviation Center, 2000). It is said to occur when the individual intentionally pays attention to the contents of working memory leading it to be absorbed into long-term memory (Herrmann, Raybeck, and Gruneberg, 2002). (More on memory stores later.)

What is learned depends very much on how it is learned. According to the Instructor Pilot's Handbook (U.S. Army Aviation Center, 2000), learning occurs through the perceptions of the five senses: sight, hearing, touch, smell, and taste. These perceptions result when a person gives meaning to the sensations and are the basis for all learning. It is important to note that a person's perceptions are influenced by several factors (or trainee characteristics, May and Kahnweiler, 2000) which do affect the gaining of knowledge, understanding, or skill. These factors are a person's 1) physical organism (the condition of the senses), 2) basic needs (physical and psychological), 3) goals and values (motivation and personal experiences), 4) self-concept (positive/negative), 5) time and opportunity (to perceive), and 6) element of threat (fear adversely affects perception) (U.S. Army Aviation Center). Considering the influence of these factors on perceptions and therefore, learning, May and Kahnweiler submit that learning *retention* is also impacted by the training design, trainee characteristics, and learning environment variables. In order to be retained, the information, once perceived, must be processed and stored through a cognitive process.

Cognitive theory

S.K. Reed (2004) defines cognition simply as the acquisition of knowledge. Such acquisition, he writes, involves many mental skills. Ashman and Conway (1997, p. 41) elaborate, "It involves taking in, storing, retrieving, transforming, and manipulating information. The process necessarily entails perception, awareness, judgment, the understanding of emotions, memory, and learning." (Note that for the discourse within this section, the author drew heavily from books by Ashman and Conway, 1997, and Reed, 2004.)

The study of thinking and learning has been influenced by two major traditions: behaviorism and human memory research. The foundation of behaviorism is that behavior is influenced by the environment in which the learning occurs. It has its base in the work of E.L. Thorndike, I.P. Pavlov, B.F. Skinner, and J.B. Watson. All have had a profound effect and impact on today's educational process. Thorndike and Pavlov manipulated the environmental conditions of animals. Thorndike's "law of effect" (using cats) was based on the premise that a correct response would lead to reinforcement and learning would occur. Pavlov, in his famous dog experiments, demonstrated that responses to conditioned stimuli can be learned and become extinct if not maintained. Skinner's methods, known as operant conditioning, were tried first on animals and later on humans. Operant conditioning is characterized by the process of learning from one step to another, with each new step dependent on a previously learned step. For Skinner, learning was the result of the reinforcement or punishment within a context controlled by the teacher. J.B. Watson, originator of the term "behaviorism," argued that researchers

should study only what could be directly observed. Basically, Watson promoted the study of the stimulus-response approach (how people responded to stimuli) without regard for the thought process involved in the response. The problem with such an approach is that it does not reveal what the person does with the information presented in the stimulus.

A change from the stimulus-response to the information-processing approach began during the 1950s. The information-processing approach (influenced by the computer metaphor) is characterized by separate stages (acquisition, storage, retrieval, and use) and attempts to depict what happens as the information is processed through these stages (Haber, 1969). In other words, this methodology attempts to reveal what the person does with the information presented in a stimulus. The information-processing approach has gathered momentum since the 1950s and has gained acceptance by today's cognitive psychologists and researchers. It has become the foundation from which theoretical frameworks (models) of cognitive architecture have been developed.

Information processing: the cognitive architecture

Theoretical frameworks for the brain's cognitive architecture have been presented and debated for many decades. Future research may discover the actual mechanisms of cognitive processing, but at present, allusions to theoretical concepts are the only recourse. An in-depth examination and assessment of every cognitive theory is not useful to this research; however, a conceptual framework is certainly helpful in illustrating the speculated process. A discussion of the most prevailing theories of the recent past follows.

In 1972, renowned researcher of human memory, F. I. M. Craik, and co-author, R. S. Lockhart, published a review of the prevailing "multistore" theories of memory which serves as the basis for some of today's concepts. The general multistore model presumed that perceived information was held in memory stores at various points in the cognitive system. After perception (the sensory stores), the information was placed in a short-term store (STS) and then could be transferred into and retained in a more permanent long-term store (LTS). Research demonstrated the distinctions between STS and LTS. It was accepted that STS had a limited capacity, whereas LTS had no known limit. Research into the STS's limited capacity was not clear as to the limiting factor: storage capacity or the rate at which the processor could perform certain operations. Craik and Lockhart favored the latter: that the limiter was the processing rate and not storage capacity. They wrote that "the concept of capacity is to be understood in terms of a limitation on processing; limitations of storage are held to be a direct consequence of this more fundamental limitation."

Finally, regarding memory and recall, Craik and Lockhart (1972) noted that many theorists of the period agreed that analysis of information proceeded through a series of sensory stages to levels associated with matching or pattern recognition and finally to semantic-associative stages of stimulus enrichment [encoding]. A result of this perceptual analysis was the creation of a memory trace. The persistence of the trace (its ability to be used and/or accessed later) was a matter of debate. Craik and Lockhart suggested that the trace persistence was a function of the depth of analysis, with deeper levels of analysis associated with more

elaborate, longer lasting and stronger traces, and that retention was a function of this depth of process.

Another plausible cognitive theory that persists and continues to be cited in the current literature (May and Kahnweiler, 2000; Pirolli and Card, 1999; Anderson and Reder, 1999a, 1999b; Blessing and Anderson, 1996) is J. R. Anderson's ACT or Adaptive Control of Thought, first described in 1983. The theory has evolved over time and has incorporated and expounded on a number of assumptions and phenomena since its original form. A simplified explanation of the theory describes a system wherein there are three major structural components and their interlinking processes: *working memory*, *declarative memory*, and *production memory*. Referring to the ACT theory, May and Kahnweiler write that skill acquisition is believed to proceed through three stages: a cognitive stage, in which a description of the procedure is learned (declarative knowledge); an associative stage, in which facts are compiled and integrated with a method for performing the skill (procedural knowledge); and an autonomous stage, in which the skill becomes more fluent and automatic. Basically, information from the outside world is encoded into a working memory which is currently accessible, followed by a storage process that creates permanent records in the long-term declarative memory (Anderson, 1983). Previously stored information in the declarative memory is accessed by the working memory when retrieval of information is necessary or desired. The production memory is engaged whenever performance and execution processes are necessary. Associated or related permanent information is connected by traces. According to the theory, a trace once formed is not lost, but its strength may decay [due to infrequent use or access].

Strengthening and retrieving traces

As indicated, the longer the time a trace is left unused, the harder it is to find amidst everything else. According to Herrmann, Raybeck, and Gruneberg (2002), the strength of memory traces can be increased through the mental manipulations that order and organize thoughts to assist registration, retention, and remembering. These trace-strengthening manipulations work 1) by intensifying learner attention during the learning, retention, and retrieval phases of the memory process and 2) by involving the rehearsal of the items to be remembered.

Strategies for enhancing the retrieval of information include techniques in association (associating a known concept/word with a new one), clustering (grouping related information), imagery, location, mnemonic devices, and visualization (Goll, 2004; Mindtools, n.d.). Herrmann, Raybeck, and Gruneberg (2002), inform 1) that association manipulations relate different traces with each other, including associating verbally, associating present information with past information, and associating meaningful, phonetic, and/or visual relationships; and 2) that traces are easier to retrieve when surprising or interesting attributes are assigned to the information, i.e., size, shape, color, judgments, description.

In his 2004 book, *Cognition: Theory and Applications*, Reed provides a superficial account of the separate stages that researchers most commonly include in information-processing models (Figure 1). According to Reed, the sensory store provides brief storage for information in its sensory form. The perceptual information is then filtered which results in the blocking of

some information, while other information is accepted or recognized. At the end of the filtering, all is lost unless a pattern is recognized (e.g., identifying a pattern as an animal or a written letter or word). Reed continues that the selection stage determines which information the person will try to remember. Following selection, the information is then moved into short-term (limited capacity in amount and duration) or long-term memory (with unlimited capacities). Note that the stages are depicted in temporal order; however, the information can flow in both directions since information in a later stage can influence the processing of new information in earlier stages.

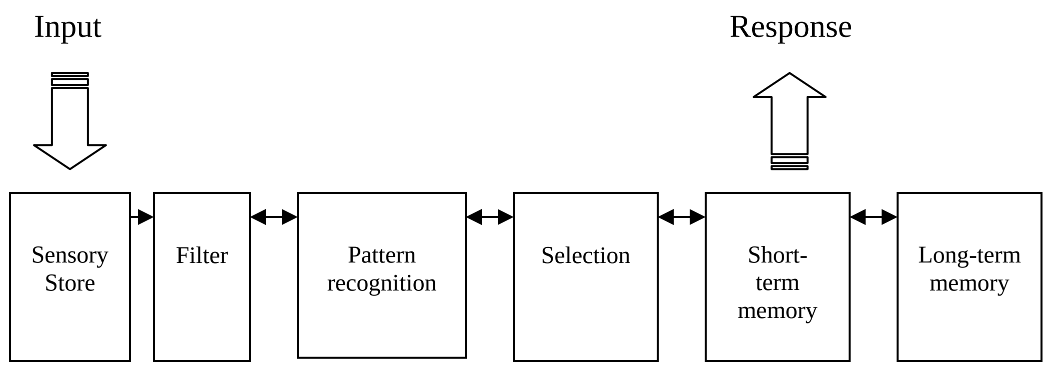


Figure 1. Stages of an information-processing model (adapted from Reed, 2004).

Having a basic understanding and conceptual framework of the cognitive process is of benefit to anyone involved in the practical exercise of conveying information. According to Ashman and Conway (1997), it is important to have a basic understanding of the brain as a working cognitive organizer. King-Friedrichs (2001) writes, "Teachers can use knowledge about how the brain remembers to help students retain [and recall] concepts."

Learning style preferences

In a paper on approaches to teaching, Munro and Rice-Munro (2004) write, "If a topic is important for students to learn, present it in a variety of ways that will stimulate learning…It's clear that there is no one instructional method that will reach all learners; therefore, it is up to those designing and delivering the instruction to offer a variety of approaches." The notion that no one teaching method will reach all learners has emerged as the result of extensive research into individual student learning style preferences, specifically, their preferred sense modality of stimuli from which they most effectively take in, process, and store new information (Harrison, Andrews, and Saklofske, 2003; Cassidy and Eachus, 2000; Dunn, 1983). Simply stated, a learning style indicates an individual's preference for different types of information, the different ways in which it is perceived, and the rate at which the information is understood (Felder, 1993). A person's learning style is said to be the combination of cognitive, affective, and psychological characteristics that describe how that individual interacts with his or her environment (Krätzig and Arbuthnott, 2006). Thus, to ensure the effectiveness of a teaching program, consideration needs to be given to the characteristics of the learner (Ashman and Conway, 1997).

The significance of learning styles gained standing as a framework in the 1970s in an effort to enrich teaching methods and explain the differences in how students learn (Brew, 2002;

Dunn and Dunn, 1979; Keefe, 1979). A discourse of learning styles is not possible without a discussion of Kolb's Experiential Learning Model (ELM) (1976). Kolb's ELM is a well established model that has attracted much interest and appreciation (Loo, 2004/2002). It continues to be influential in the educational and management fields (Brew, 2002).

According to Kolb (1976), his model is labeled *experiential* to emphasize the important role experience plays in the learning process: "The core of the model is a simple description of the learning cycle: how experience is translated into concepts, which in turn are used as guides in the choice of new experiences." Kolb's model is a four-stage cycle (Figure 2) which describes how learners see and interpret information: experience is translated into concepts, which then guide the choice of new experiences (Wolfe, Bates, Manikowske, and Amundsen, 2005). Kolb writes:

> These observations are assimilated into a theory from which new implications for action can be deduced. These implications or hypotheses then serve as guides in acting to create new experiences. The learner, if he is to be effective, needs four different kinds of abilities: concrete experience (CE), reflective observation (RO), abstract onceptualization (AC), and active experimentation (AE).

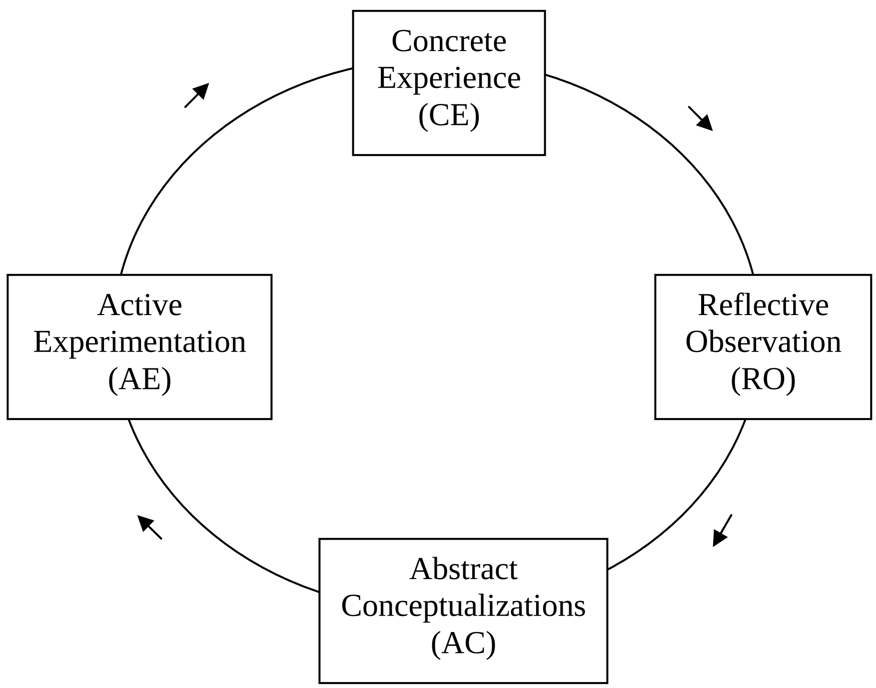


Figure 2. Kolb's Experiential Learning Model (adapted from Kolb, 1976).

Kolb (1976) questions whether anyone can become highly skilled in all of the four abilities. He submits that learning requires abilities that are polar opposites and that the learner, as a result, must continually choose which set of abilities he will bring to bear in any specific learning situation. Therefore, he suggests that the learning process possesses two primary dimensions: how individuals perceive the information (concrete experience or abstract

conceptualization) and how they process the information (using active experimentation or reflective observation) (Kolb; Brew, 2002; Loo, 2004; Wolfe, Bates, Manikowske, and Amundsen, 2005). Kolb concluded that most people emphasize some learning abilities over others and, thus, develop learning styles that are based on their heredity, past experience, and the demands of their present environment.

To complement his theory, Kolb (1976) developed a learning style preference instrument, the Learning Style Inventory (LSI), from which individual strengths and weaknesses as a learner are measured. Essentially, the instrument measures the individual's relative emphasis on the four learning abilities listed earlier. The LSI results in the identification and labeling of four learning styles: divergers, convergers, assimilators, and accommodators. These styles are derived from and form the four quadrants of Kolb's ELM (Figure 3).

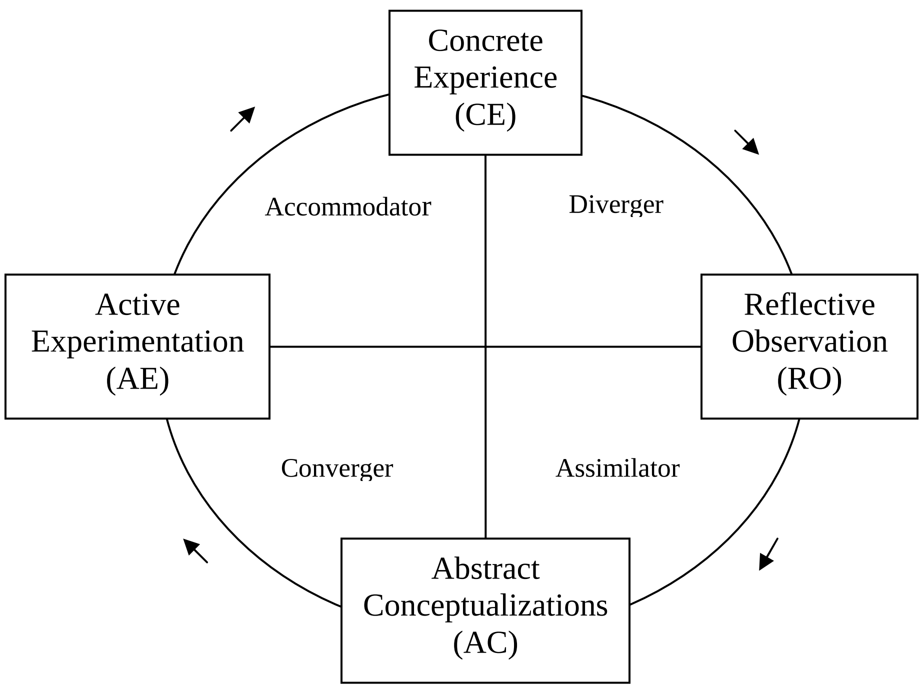


Figure 3. Kolb's Experiential Learning Model and four learning styles (adapted from Loo, 2004).

According to Kolb (1976), *divergers* are best at CE and RO and therefore, have great imaginative ability, can view concrete situations from many perspectives, are interested in people, and are creative. *Convergers* are the opposite, with AC and AE their dominant learning abilities. They are strong in the practical application of ideas and can focus on specific problems using hypothetical-deductive reasoning. They are pragmatic and logical (Wolfe, Bates, Manikowske, and Amundsen, 2005), have narrow technical interests, and hence, tend to specialize.

Assimilators possess robust AC and RO learning abilities which give them strength at creating theoretical models and allows them to excel in inductive reasoning. Assimilators have concern for abstract concepts, but are less interested in the practical use of theories or people. *Accommodators,* on the other hand, are the converse of the assimilators. They are best at CE and AE, which means they are best at doing things. They accomplish things, are risk takers, and are the best at adapting themselves to specific situations. Where theory and fact disagree, accommodators will most likely discard the theory.

Kolb's LSI has been controversial and criticized by some as weak (Loo, 2004; Sadler-Smith, 1997) and at worst, possessing questionable validity and reliability (Freedman and Stumpf, 1978; for rebuttal see Kolb, 1981; Brew, 2002). Studies have shown that learning style is not a major determinant of learning preference (Loo).

Visual perception

As detailed earlier, perceptions through the senses are the first steps in the cognitive process. Normal individuals acquire 75% of their knowledge through their sense of sight (U.S. Army Aviation Center, 2000). In the context of visual perception, Dretske (1995) makes a distinction between sense perception and meaningful perception. Meaningful perception refers not to the objects one sees, but to *how* one perceives them. This meaningful perception embodies a judgment, belief, or recognition and requires conceptual skills, thus, requiring some level of *visual cognition*. This cognitive quality of visual perception has been the focus of past and current research and is the foundation on which the IPS, the proposed novel approach to teaching utilizing pictorial representations, is based.

As early as 1886, research by James McKeen Cattell (Carr, 1986) discovered that people could recognize a single color or shape in a slightly shorter time than a word or letter; however, it took them longer to name it. Cattell explained:

> …this is because in the case of words or letters that association between the idea and the name has taken place so often that the process has become automatic, whereas, in the case of colours [sic] and pictures we must by voluntary effort choose the name.

In 1982, Carr, McCauley, Sperber, and Parmelee (Carr, 1986) replicated Cattell's experiments and came to the same conclusions, adding further legitimacy to Cattell's experiments. Findings from similar research by Potter, Kroll, and Harris (1979) on the speed in which words or pictures are named were compatible with Cattell's conclusions: that words and pictures are read just alike, except that words, being so practiced, make the process of *naming* them more efficient and automatic. If naming is faster with words, then what about the *meaning* of the stimulus rather than its name? Research by Potter and Faulconer (1975) answered that interesting question. Their research found that although words were named faster than pictures, pictures were classified faster than words. Their findings indicate that although words may bear a closer relationship to their pronunciations (at least in a phonetic language), pictures bear a closer relationship to their meanings (Carr, 1986). Research has shown that pictures possessing meanings can serve as aids to memory.

Visual memory

Early research by Shepard (1967) into recognition memory found that stimuli recalled from pictures were correctly recognized by 98% of the participants compared to 90% for words and 88% for sentences. Comparable research by Nickerson (1965) arrived at similar conclusions. Nickerson wrote that although his experiment differed procedurally in several important respects, the results of his project substantiated Shepard's finding "of exceptionally high recognition memory performance with pictorial material."

Memory research in the 1960s by Haber (1970) suggested that there was one kind of memory for linguistic information (words, numbers, etc.) and another for pictorial information (scenes, pictures, etc.). According to his conclusions, each kind of memory handled the visual information differently. In the case of words, text, and numbers, "the first step of memory is to take the stimulus out of its visual, pictorial form, code the items, and extract their meanings" (Haber). Words are remembered, not as a picture of their letters, but as an idea or concept of the word(s). This requires several steps of encoding for proper storage and retrieval. Evidence from Haber's research indicated that this was not the case with pictorial information. He suggested that the pictorial image was received and stored permanently in its pictorial form. Haber wrote that "the capacity of memory for pictures may be unlimited."

The capacity of the human mind to retain recognition of previously viewed scenes (pictures) has been the focus of numerous studies over the past 35 years which have repeatedly confirmed the mind's extraordinary ability to discriminate previously viewed objects and scenes from hundreds of distracters (Standing, Conezio, and Haber, 1970; Potter, 1976; Simons, 1996; Hollingworth, Williams, and Henderson, 2001; Hollingworth and Henderson, 2002). By and large, during recognition studies, subjects are shown a number of scenes first. This exercise is followed by a second set of scenes which contains previously viewed scenes plus new ones. Subjects must then identify the pictures that were previously seen in the first viewing. The studies have shown that the participants perform exceedingly well even when thousands of pictures are shown. Hollingworth, Williams, and Henderson report that the results of their study "demonstrate that visual object representations are retained in memory [and that] the study supports a view of scene perception in which memory and perceptual processing are functionally integrated."

According to research conducted on the brains of humans and monkeys (Keysers, Xiao, Földiák, and Perrett, 2005), neurons in the temporal cortex continue processing briefly-flashed visual stimuli (pictures) as if they were still present. This continued firing of neurons may underlie the increased memory for pictures and icons. Kosslyn (2005) writes that the "visual cortex supports depictive representations during perception, not descriptive ones…this is strong evidence that imagery does not rely exclusively on the same sorts of representations that underlie language."

Pictorial representations

With an understanding of visual cognition and with scientific evidence of the mind's exceptional capacity for the recall of images, a search for literature examining the practical

application of pictorial systems was conducted. Understanding the role of pictorial illustrations for improving memory and verbal recall is necessary in the design and employment of such a system.

In 1993, Morrell and Park published a report of a study during which adults were instructed to build a 3-dimensional object from three types of instructions (text only, illustration, or text and illustration). The findings indicated that instructions consisting of both text and illustrations reduced errors compared to the other formats. A study in 1996 by Cherry, Park, Frieske, and Smith, found that pictorial illustrations had a positive effect on younger and older adults' recall of adjectives. A similar study by Cherry, Dokey, Reese, and Brigman (2003), tested the effects of verbal and pictorial illustrations on younger and older adults' recall of the content of short sentences. Positive effects of pictorial illustrations were observed and the data were clear that both groups benefited from the mere presence of pictures. The authors write, "With an eye toward everyday memory practices, this aspect of the data suggests that pictorial illustrations should be included in instructional formats that are designed to promote learning and retention of written materials in everyday life for both younger and older adults."

There are aspects of pictorial representations, however, that must be considered when including pictorial representations in learning material. Pictorial representations must be supported by substantive explanations and/or instruction. Watkins, Miller, and Brubaker (2004) note that most students tend to rely solely on illustrations, when they are present, to the exclusion of captions or explanatory text. This propensity to ignore the supporting text results in the construction of their own interpretations, thus, leading to misconceptions of the information. In fact, Morgan (2005) discovered that participants in a study of magazine advertisements do infer a consistent set of claims, but also arrive at multiple meanings (interpretations and conceptions) within each advertisement. With this in mind, precautions should be taken to ensure that pictorial representations are perceived and understood as intended.

<u>IPS symbols</u>

When designing symbols, especially those purporting to be intuitive as with the IPS, many of the constructs and guidelines utilized by computer software designers are useful and relevant. Designers devise symbols (visual representations) as interfaces between the human and the machine creating a language of symbols and metaphors (Szewczyk, 2003). Such symbols are referred to as graphic user interfaces or GUI (pronounced GOO-ee). Ambler (2000, quoted by Szewczyk) notes that the GUI structure includes icons, palettes, dialogues, and cursor shapes. According to Ambler, the layout of the symbols influences the way the user can interpret it and the relations between pieces of the GUI structure add some new meanings to the visual languages of the interfaces.

Referring to [Worldwide] Web interface design, but still applicable to the proposed IPS, Dr. R.H. Miller (n.d.), Project Manager for Bell Communications Research, writes that when designing icons, it is important ask several key questions:

- Is the design simple?
- Is the meaning clear for the intended audience?

- Does any action represented in the icon standout? (emphasize the action since it is hard to present motion in an icon)
- Are you using consistent and appropriate metaphors?
- If "yes" can be answer to all of the questions above, then ask, "Is the icon unique?"

In Szewczyk's 2003 study of computer-aided design (CAD) students, he drew some inferences from the results concerning the students' perception of the CAD GUI:

1. If an unknown icon looked similar to a well-known icon, students supposed that the unknown icon represented the same function. The students used empirical knowledge and demonstrated a strong desire to associate unknown icons with those that were well known.
2. If an icon was a picture of a real thing, students supposed that it could be used to create or modify the virtual representation of such a thing. Using obvious and simple metaphors improves the association to the real thing.
3. Abstract icons misled students and created problems wherein students' perceptions of the icons were extremely individualistic. Interestingly, inexperienced CAD students (second-semester) tended to guess more at the icons' meanings and gave many incorrect answers, while the more experienced students (sixth-semester) avoided guessing and did not answer or comment as to their meanings.
4. In keeping with Number 3 above, the inexperienced students tried to make sense out of any icon, while the more experienced students, having a fundamental knowledge of icons, did not seem to see the necessity in learning or guessing at every icon.
5. The layout of GUI symbols can affect the understanding of each symbol. Inexperienced students, in their effort to make sense out of any icon, had a better sense of the context in which the icons appeared. In contrast, experienced students, who typically ignored unknown icons, failed to become aware of the context in which the icons appeared. Their focus remained on the known icons.

The symbols (Appendix A) which make up the IPS were developed consistent with the above guiding principles.

Conceptual framework

In order to test whether the form in which information is presented (taught) results in any change in retention and therefore, the recall of the information, the conceptual framework consists of a series of entities (Figure 4). The visual form in which the information is presented affects the way in which it is perceived by the student. Theory suggests that pictures are perceived differently than text. Such perceptions produce a visual memory that, if meaningful, produces visual cognition. Cognition or learning occurs when the information is processed (encoded) and moved from short-term memory to long-term memory. Mnemonic strategies, such as those representing information in pictorial form, have demonstrated the capacity to facilitate such encoding and studies indicate considerable success when using such strategies in

the retention and recall of the information learned. Thus, *improved memory performance* is the ultimate construct of the proposed study.

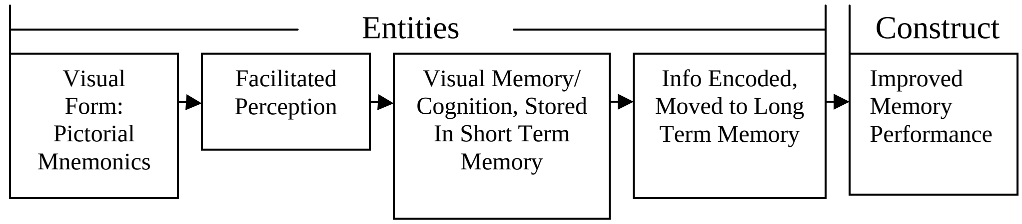


Figure 4. Conceptual framework of the study.

Research hypotheses

Based on the theoretical and empirical research regarding the construct of this study, the proposed study will test the following research hypotheses:

H_{01}: Based on performance test scores, there is no difference in the demonstrated retention and recall of aviation emergency procedures between the traditional and novel teaching methods in the overall sample population.

H_{A1}: Based on performance test scores, there is a difference in the demonstrated retention and recall of aviation emergency procedures between the traditional and novel teaching methods in the overall sample population.

H_{02}: Based on performance test scores, there is no difference between those taught using the traditional method and those taught using the IPS method with respect to experience levels.

H_{A2}: Based on performance test scores, there is a difference between those taught using the traditional method and those taught using the IPS method with respect to experience levels.

H_{03}: Based on performance test scores, there is no difference between those taught using the traditional method and those taught using the IPS method with respect to individual learning style preferences.

H_{A3}: Based on performance test scores, there is a difference between those taught using the traditional method and those taught using the IPS method with respect to individual learning style preferences.

H_{04}: Recall performance is not related to the manner in which the IPS is subjectively assessed.

H_{A4}: Recall performance is related to the manner in which the IPS is subjectively assessed.

H_{05}: Based on opinion data, individual learning style preferences do not have an effect on aviators' subjective assessment of the IPS (using pictorial mnemonics) as an aid in memorizing textual aviation emergency procedures.

H_{A5}: Based on opinion data, individual learning style preferences do have an effect on aviators' subjective assessment of the IPS (using pictorial mnemonics) as an aid in memorizing textual aviation emergency procedures.

H_{06}: Based on opinion data, experience levels have no effect on aviators' subjective assessment of the IPS (using pictorial mnemonics) as an aid in memorizing textual aviation emergency procedures.

H_{A6}: Based on opinion data, experience levels do have an effect on aviators' subjective assessment of the IPS (using pictorial mnemonics) as an aid in memorizing textual aviation emergency procedures.

H_{07}: Based on opinion data, the novel IPS was not positively assessed by the majority of those in the treatment groups as a useful pictorial mnemonic for remembering textual aviation emergency procedures.

H_{A7}: Based on opinion data, the novel IPS was positively assessed by the majority of those in the treatment groups as a useful pictorial mnemonic for remembering textual aviation emergency procedures.

H_{08}: Based on symbol recognition test scores, there is no difference in the ability to easily recognize and remember the IPS symbols from Day 1 to Day 7.

H_{A8}: Based on symbol recognition test scores, there is a difference in the ability to easily recognize and remember the IPS symbols from Day 1 to Day 7.

H_{09}: Based on posttest performances, there is no association between committed study time from Day 1 to Day 7 and test performances.

H_{A9}: Based on posttest performances, there is an association between committed study time from Day 1 to Day 7 and test performances.

Research methodology

Research designs

Primarily, this study tested the merits of the IPS through a true experimental design: a pretest-posttest control group design (Leedy and Ormrod, 2001). The design was applied to three distinct membership groups based on their experience levels and, thus, their exposures to the traditional training method. This was desired in an effort to gain further insight into the applicability, perceptions, and assessments of the IPS based on pilots' experience levels. The first membership group (MG 1) was comprised of instructor pilots considered highly experienced

in traditional emergency procedure training. The second membership group (MG 2) was comprised of student pilots with minimal experience in traditional emergency procedures training. Members of MG 2 were student pilots undergoing training in the U.S. Army's UH-60 Black Hawk helicopter aircraft qualification course. The third group (MG 3) was comprised of students waiting to start flight school (naïve to emergency procedure training). The intent of testing this group was to derive insight into which of the two training methods, the traditional or novel, was most effective in causing learning, retention, and recall when presenting the information to students who were naïve to any previous aviation emergency procedures training.

Consistent with the experimental design, an experimental or treatment group and a control group was selected by random assignment within each membership group. On Day 1, the knowledge of the treatment group was pretested (Emergency Procedures Knowledge Test, Appendix B), subjected to the treatment (trained in the use of the novel IPS), and then posttested with the same test. The control group on Day 1 was pretested, received training/review of the emergency procedures in the traditional manner, and posttested. The treatment and control groups of each membership group were posttested seven days later. Each posttest was intended to measure the learning, retention, and recall of the treatment group compared to that of the equivalent control group. Figure 5 depicts the paradigm for the design.

	Group	*Time* *Day 1* →			*Day 7*
Random Assignment	Treatment Group	Pretest	Novel Training (Treatment)	Posttest	Posttest
	Control Group	Pretest	Traditionally trained	Posttest	Posttest

Figure 5. Pretest-Posttest control group design (Leedy and Ormrod, 2001).

In order to test the IPS's merit as a mnemonic strategy, and the intuitiveness and memorable qualities of the IPS symbols themselves, the treatment groups of each membership group received two additional tests: the Subjective Assessment Survey (Appendix D) and the Symbol Recognition Test (Appendix F). These tests were administered immediately following treatment on Day 1 and then again Day 7. The design is that of an equivalent time-samples design (Leedy and Ormrod, 2001) and is depicted in Figure 6. Note the absence of the pretest.

	Group	*Time* *Day 1* →		*Day 7*
Random Assignment	Treatment Groups	Novel Training (Treatment)	Posttest	Posttest

Figure 6. Equivalent time-samples design: MGs 1, 2, and 3 Treatment Groups (Leedy and Ormrod, 2001).

Signed informed consents were obtained from each participant prior to his or her participation. All identifying data were separated from test data and were stored in a locked safe in the USAARL Science Information Center for a minimum of three years.

Participants and setting

As described above, the study population consisted of three distinct membership groups: highly-experienced instructor pilots (MG 1), minimally-experienced student pilots (MG 2), and naïve students waiting to start flight school (MG 3). All participants were recruited from personnel assigned to Fort Rucker, Alabama, and were identified through local advertisement and solicitation. Fort Rucker is the location of the U.S. Army Aviation Warfighting Center (USAAWC). All training and testing for this study occurred in the aviation training classrooms at Lowe Army Heliport or in a USAARL meeting room, both located at Fort Rucker, Alabama.

Sample size

The sample size required to achieve a sufficient power to examine the potential of the IPS strategy was performed using the DSS Research calculator, an online power calculation tool (DSS Research, n.d.). The power calculation was conducted specifying a desired power of .80, an a level of .05, and a large effect size (d = 1.00). The effect size of 1.00 was based on the results of a study by Carney and Levin (2003). Carney and Levin's work examined the effects of training undergraduate students in the use of mnemonic strategies (pictorial representations) on their memory and recall of unfamiliar hierarchical information, which was sufficiently similar to the objectives of this study. With these specifications and Carney and Levin's findings as a basis for the power calculation, 30 participants per membership group (15 per treatment group and 15 per control group) were required to ensure an 80% chance of rejecting a false null hypothesis. Hence, this study required a total n size of 90, 30 per membership group.

Data collection tools

Emergency Procedures Knowledge Test

The Emergency Procedures Knowledge Test (Appendix B) for all membership groups consisted of a 15-question fill-in-the-blank written examination covering 17 selected emergency procedures listed in the UH-60 Black Hawk Operator's Manual (Headquarters, Department of the Army, 2003). The test had a total of 25 answers with each answer worth four points; thus, the final test scores ranged from 0% to 100% correct and were scored using the answer sheet in Appendix C.

VARK© Learning Styles Questionnaire

The VARK© Learning Styles Questionnaire (n.d.) (Appendix H) provided a profile of user learning preferences: visual (information displayed in charts, graphs, symbols), aural (heard, spoken), read/write (words, text), kinesthetic (experience, practice) and multimodal (combination of several styles). (Permission to use the VARK questionnaire was granted by Mr. Neil D.

Fleming, Christchurch, New Zealand, holder of the copyright, on August 27, 2005.) VARK categories were determined according to the scoring procedures in Appendix I.

Subjective Assessment Survey

The Subjective Assessment Survey (Appendix D) consisted of a series of questions aimed at determining the merits of the IPS as a mnemonic strategy based on the opinions of the users. The responses were made on a five-point Likert scale (Wikipedia, n.d.) ranging from *strongly disagree* to *strongly agree*. Solicitation for additional comments was made. Scoring was performed per the instructions in Appendix E.

Symbol Recognition Test

The Symbol Recognition Test (Appendix F) was a 20-symbol, fill-in-the-blank test that was intended to gauge the intuitiveness and memorable quality of the IPS symbols. The test had a total of 20 answers with each answer worth 5 points, thus, the final test scores ranged from 0% to 100% correct. Scoring was performed using the answer sheet in Appendix G.

Study Experience Report

The Study Experience Report (Appendix J) was added to the study on the recommendation of the USAARL Science Program Director to gauge the study efforts of the sample population. The report collected an estimate of the time spent studying the emergency procedures presented as part of this research, with and without using the IPS symbols as appropriate to the assigned group.

Research variables

Research variables were derived from each of the data collection instruments described above and employed as independent variables (IV), dependent variables (DV), or covariates (CV). Table 1 presents the research variables and their functions in addressing each research question (RQ).

Table 1.
Research variables.

RQ	Variables	Variable Function	Variable Type/ Level of Measurement
1	Method of Training Knowledge Test Change Scores	IV DV	Categorical/Nominal Continuous/Ratio
2	Method of Training Experience Level Knowledge Test Change Scores	IV IV DV	Categorical/Nominal Categorical/Nominal Continuous/Ratio
3	Method of Training Learning Style Preference Knowledge Test Change Scores	IV IV DV	Categorical/Nominal Categorical/Nominal Continuous/Ratio
4	Subjective Assessment Knowledge Test & Change Scores	DV (predictor) DV (outcome)	Categorical/Ordinal Continuous/Ratio
5	Learning Style Preference Subjective Assessment	DV (predictor) DV (outcome)	Categorical/Nominal Categorical/Ordinal
6	Experience Level Subjective Assessment	DV (predictor) DV (outcome)	Categorical/Nominal Categorical/Ordinal
7	Subjective Assessment	Descriptive	Categorical/Ordinal
8	Experience Level Symbol Recognition Scores	IV DV	Categorical/Nominal Continuous/Ratio
9	Study Experience Knowledge Test Change Scores Symbol Recognition Change Scores	DV (predictor) DV (outcome) DV (outcome)	Continuous/Ratio Continuous/Ratio Continuous/Ratio

Note: RQ = Research Question; IV = independent variable; DV = dependent variable.

Procedures

Each potential participant was briefed on the objectives of the study. If continued participation was indicated, each participant was given adequate time to review and understand all the information in the informed consent form before agreeing to take part in the research study. After signing the informed consent, the participants were randomly assigned to either a treatment group or a control group and assigned to the appropriate experience level membership group: MG 1, MG 2, or MG 3 (30 participants per membership group for a total of 90). The importance of not discussing any aspects of the study with anyone other than those within their assigned membership groups was stressed. Participants were instructed on what date to report for Day 1. Each group (treatment or control) was managed on different days and times of the week in order to eliminate any interaction between groups of different experience levels (MGs).

Group reporting times remained flexible in order to accommodate participant flight training and/or work schedules. In order to avoid any subject bias possibly introduced by the words "novel" and "traditional," the terms "Method 1" and "Method 2", respectively, were used whenever interacting with the subjects.

Data collection

On Day 1 for a given group, each participant completed a VARK© Learning Preference Questionnaire (Appendix H). Following that, each group received a general information briefing (Appendix K) and was administered the Emergency Procedures Knowledge Test (Appendix B) as a pretest.

Next, depending on their group of assignment, members were provided training of aviation emergency procedures by either Method 1 (novel) or Method 2 (traditional). The training consisted of classroom instruction supported by PowerPoint presentations during which a UH-60 aircraft/cockpit orientation/review was presented (Appendix L). This orientation/ review was followed by training on the 17 selected emergency procedures (Appendix M or N, depending on group assignment) listed in the UH-60 Black Hawk Operator's Manual (Headquarters, Department of the Army, 2003). It is important to realize that non-underlined steps in the Operator's Manual are not routinely memorized, only the underlined steps. However, as a condition of this research, non-underlined steps of the selected emergency procedures were required to be memorized. This ensured that even experienced aviators had to apply some memorization techniques (their own or the IPS depending on group assignment) during their participation in this study.

At the completion of the training, the Emergency Procedures Knowledge Test (Appendix B) was administered again as a check on learning (posttest, Day 1). In addition, members of the treatment group (receiving Method 1) were administered the Symbol Recognition Test (Appendix F) and were provided with a paper copy of Appendix A, Intuitive Pictorial System Symbols and Rules, for additional review and study. Members of the groups received a paper copy of their appropriate PowerPoint presentation slides (Appendix M or N). On Day 7, the same Emergency Procedures Knowledge Test (Appendix B) was administered as a second posttest. Following the posttest, a Subjective Assessment Survey (Appendix D) was administered to the members of the treatment groups in order to gather opinion-based data regarding the merits of the novel IPS. The Symbol Recognition Test (Appendix F) was re-administered to the treatment groups only and all groups were asked to estimate time spent studying over the previous week (Appendix J).

The preceding data collection procedures are summarized in Table 2.

Table 2.
Event and data collection summary.

	Treatment Groups	Control Groups
Screening Day		
- Briefing of Study Objectives - Informed Consents Completed - Random Group Assignments Made - Establish Group Reporting Dates & Times	All participants	
Day 1		
- VARK Learning Preference Questionnaire	X	X
- General Information Briefing	X	X
- Emergency Procedures Knowledge Test (pretest)	X	X
- Instructional PowerPoint Presentation	†	‡
- Emergency Procedures Knowledge Test (posttest 1)	X	X
- Symbol Recognition Test	X	
- Hand out paper copies of instructional material	†	‡
Day 7		
- Emergency Procedures Knowledge Test (posttest 2)	X	X
- Subjective Assessment Survey	X	
- Symbol Recognition Test	X	
- Study Experience Report	X	X

Note: † = with IPS instructions/symbols; ‡ = without IPS instructions/symbols.

Testing and analysis of the data

The testing and analyses of the data for this study were conducted using SPSS® 12.0 with statistical significance set at the .05 level and confidence intervals at 95%. The data collection effort resulted in the minimum number of participants required per the power analysis (a minimum of 15 in each group). The final total was 93 as depicted in Table 3.

Table 3.
Sample population totals.

MG 1 Highly-experienced Pilots		MG 2 Minimally-experienced Student Pilots		MG 3 Naïve Group	
Treatment	Control	Treatment	Control	Treatment	Control
15	15	17	15	16	15

Note: MG = Membership Group

The results are presented in the order of research hypotheses and associated research questions presented in Chapters 2 and 3.

Hypotheses H_{01} and H_{A1}

To address Hypotheses H_{01} and H_{A1} and answer whether the employment of the IPS would demonstrate improved retention and recall of emergency procedures over that of the traditional teaching method in the overall sample population, two comparisons were made of the Emergency Procedures Knowledge Test change scores: 1) Day 1 Pretest and Day 1 Posttest, and 2) Day 1 Posttest and Day 7 Posttest. An initial exploration of the test score data provided the descriptive statistics presented in Table 4.

Table 4.
Emergency Procedures Knowledge test descriptive statistics for total sample population.

	Treatment/ Control	n	Mean	Standard Deviation	Std. Error Mean
Day 1 Emergency Procedures Knowledge Pretest	Treatment	48	56.25	37.318	5.386
	Control	45	47.29	33.589	5.007
Day 1 Emergency Procedures Knowledge Posttest	Treatment	48	65.00	28.945	4.178
	Control	45	66.49	22.471	3.350
Day 7 Emergency Procedures Knowledge Posttest	Treatment	48	72.83	22.048	3.182
	Control	45	73.51	20.276	3.023
Day 1 Pretest / Day 1 Posttest Change Scores	Treatment	48	8.75	12.985	1.874
	Control	45	19.20	19.551	2.915
Day 1 Posttest / Day 7 Posttest Change Scores	Treatment	48	7.83	17.754	2.563
	Control	45	7.02	15.682	2.338

During the initial data exploration, a Shapiro-Wilk test of normality was performed. Note that a Shapiro-Wilk test resulting in a low significance value (less than .05) indicates that the distribution of the data differs significantly from a normal distribution. The Shapiro-Wilk tests of the Day 1 Pre-/Posttest change scores for the control group and of the Day 1/Day 7 Posttest change scores for the treatment group showed that these data were not normally distributed [$W(45) = .913$, $p = .003$ and $W(48) = .897$, $p = .001$, respectively]. Attempts to transform the data did not change its condition. Therefore, the nonparametric Mann-Whitney U test was used in lieu of the originally-planned independent-samples *t* test as the test for comparing the performance of the treatment and control instructional methods.

Between methods

In the first comparison (Day 1 Pretest to the Day 1 Posttest), the results indicated that in the overall sample population, there was a significant performance difference between the treatment and control instructional methods. The control method demonstrated a significantly greater average improvement ($U = 734.50$, $p = .008$) in performance than did the treatment method (19.2 vs. 8.75, respectively). Therefore, for this first comparison, the results indicate a rejection of the null hypothesis (H_{01}) and support for the alternative (H_{A1}). The results answer

the research question by revealing that the use of the IPS did not demonstrate improved retention and recall of emergency procedures over that of the traditional teaching method in the overall sample population.

In the second comparison, the Mann-Whitney U test showed that there were no significant differences in the performance changes between groups (aggregate treatment and control instructional methods) from Day 1 to Day 7 (U = 1051.00, $p = .823$). In this case, the null hypothesis (H_{01}) was found to be true.

Within methods

A check of within-method performances using the nonparametric Wilcoxon's Signed-Rank test (alternative to paired samples *t* test) revealed that each method group made statistically significant improvements in their posttest performances from Day 1 to Day 7. Within the treatment instructional method, an improvement from a mean of 65.00 to 72.83 ($p = .007$) was noted, while the control instructional method improved from a mean of 66.49 to 73.51 ($p = .007$).

Hypotheses H_{02} and H_{A2}

To test the Hypotheses H_{02} and H_{A2}, a Kruskal-Wallis test (nonparametric alternative to an ANOVA) was employed to answer whether there was a difference in the recall performance between those taught using the traditional method and those taught using the IPS method with respect to experience levels (MGs). This was followed by a Median test which is used to determine whether any patterns represented significant group differences. Detailed descriptive statistics for the EP Knowledge test scores and change scores are presented in Tables 5 and 6. Individual graphs (Figures O-1 through O-3) for the EP Knowledge test and change scores by membership group are available in Appendix O. Figure 7 presents a summary of the mean scores for each of the EP Knowledge tests by membership group.

Table 5.
Emergency Procedures Knowledge test score descriptive statistics by membership group

	Membership Group	Treatment/ Control	n	Mean	Std. Deviation	Min	Max
Day 1 EP Knowledge Pretest	MG 1	Treatment	15	80.00	17.370	40	100
		Control	15	76.80	14.674	48	96
	MG 2	Treatment	17	81.65	11.230	64	100
		Control	15	59.47	16.621	32	88
	MG 3	Treatment	16	7.00	8.066	0	28
		Control	15	5.60	10.006	0	40
Day 1 EP Knowledge Posttest	MG 1	Treatment	15	82.67	16.189	52	100
		Control	15	84.80	15.580	56	100
	MG 2	Treatment	17	83.29	12.429	60	100
		Control	15	68.00	19.654	40	100
	MG 3	Treatment	16	29.00	11.911	4	44
		Control	15	46.67	13.238	16	64
Day 7 EP Knowledge Posttest	MG 1	Treatment	15	88.00	9.798	64	100
		Control	15	84.53	15.108	60	100
	MG 2	Treatment	17	80.47	15.025	44	100
		Control	15	79.20	12.394	64	96
	MG 3	Treatment	16	50.50	19.093	24	88
		Control	15	56.80	21.123	20	88

Note: MG = Membership Group; Min = minimum; Max = maximum.

Table 6.
Emergency Procedures Knowledge test change score descriptive statistics by membership group.

	Membership Group	Treatment/ Control	Mean	n	Std. Deviation	Min	Max
Day 1 Pretest to Day 1 Posttest Change Scores	MG 1	Treatment	2.67	15	8.902	-16	20
		Control	8.00	15	7.856	-12	20
	MG 2	Treatment	1.65	17	7.491	-8	16
		Control	8.53	15	10.350	-12	24
	MG 3	Treatment	22.00	16	10.633	4	40
		Control	41.07	15	16.246	4	60
Day 1 Posttest to Day 7 Posttest Change Scores	MG 1	Treatment	5.33	15	14.316	-8	44
		Control	-.27	15	7.324	-12	12
	MG 2	Treatment	-2.82	17	10.273	-20	16
		Control	11.20	15	13.455	-12	32
	MG 3	Treatment	21.50	16	18.698	-4	56
		Control	10.13	15	21.267	-32	44

Note: MG = Membership Group; Min = minimum; Max = maximum.

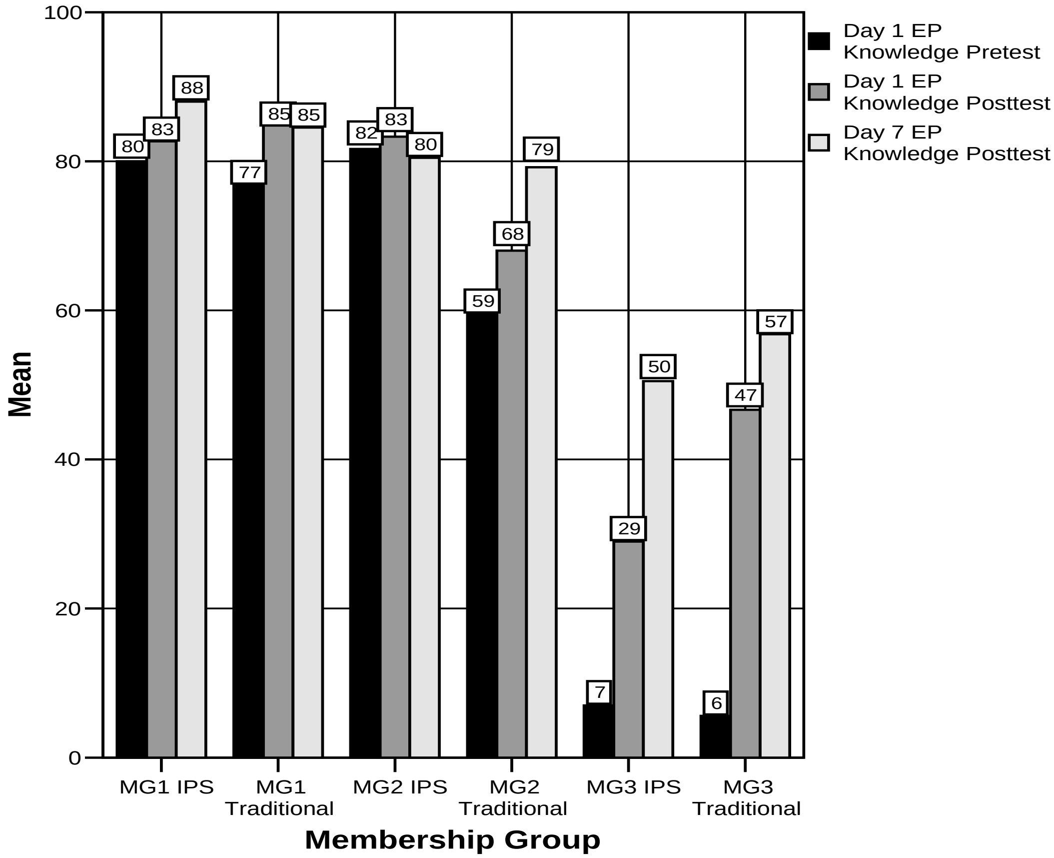


Figure 7. Summary of Emergency Procedures Knowledge test score means by membership group. (MG = membership group; IPS = Intuitive Pictorial System)

In an analysis of these data, the Kruskal-Wallis test detected that significant differences existed in the changes in EP Knowledge test scores from Day 1 Pretest to Day 1 Posttest and from Day 1 Posttest to Day 7 Posttest with respect to experience levels (Table 7), hence, rejecting the null hypothesis (H_{02}) in favor of the alternative (H_{A2}).

The Median test (Table 8) and its test statistics (Table 9) indicated that, both, the treatment and control groups of MG 3 (naïve group), achieved significant improvements in their scores from the Day 1 Pretest to the Day 1 Posttest (in bold). The same Median test and statistics revealed a significant difference by experience levels in performance gains (change scores) between the Day 1 Posttest and the Day 7 Posttest. The majority of the naïve (MG 3) treatment group and of the control groups of the minimally-experienced (MG 2) and naïve (MG 3) participants improved their scores greater than the median improvement of their respective group populations (in bold, Table 8).

The majority of the highly-experienced group did not show performance gains greater than the median of their respective groups. This is likely due to a ceiling effect. That is, their preexisting high level of EP Knowledge competence may be so high that treatment effects are not perceptible or obscured (Clarion University of Pennsylvania, n.d.).

Table 7.

Kruskal-Wallis Test statistics for Emergency Procedures Knowledge test change scores by treatment and control membership groups with respect to experience.

	Day 1 Pre-/Posttest		Day 1/Day 7 Posttests	
	Treatment	Control	Treatment	Control
Chi-Square	24.442	22.905	17.012	6.155
df	2	2	2	2
Asymptotic Significance	.000**	.000**	.000**	.046*

Note: Grouping Variable: Membership Group; * $p < .05$; ** $p < .01$.

Table 8.

Median Test for Emergency Procedures Knowledge test change scores by treatment and control membership groups with respect to experience.

		Treatment Groups			Control Groups		
		MG 1	MG 2	MG 3	MG 1	MG 2	MG 3
Day 1 Pre-/Posttest	> Median	3	3	**14**	3	4	**14**
	<= Median	12	14	**2**	12	11	**1**
Day 1/Day 7 Posttests	> Median	4	4	**13**	2	**9**	**9**
	<= Median	11	13	**3**	13	**6**	**6**

Note: MG = membership group

Table 9.
Median Test statistics for Emergency Procedures Knowledge test change scores by treatment and control membership groups with respect to experience.

	Day 1 Pre-/Posttest		Day 1/Day 7 Posttests	
	Treatment	Control	Treatment	Control
n	48	45	48	45
Median	8.00	12.00	4.00	4.00
Chi-Square	20.761	19.821	13.746	8.82
df	2	2	2	2
Asymptotic Significance	.000**	.000**	.001**	.012*

Note: Grouping Variable: Membership Group; * p < .05; **p < .01.

Hypotheses H_{03} and H_{A3}

The Kruskal-Wallis and Median tests were again employed to address Hypotheses H_{03} and H_{A3} due to the data's non-normal distribution. The research question inquired whether individual learning style preferences (visual, aural, read/write, kinesthetic, or multimodal) had an effect on the recall performance of individual membership groups taught using either the traditional method or the IPS method. Figure 8 summarizes the number of participants classified through the VARK Questionnaire (Appendix C) as to their learning style preference per membership group. The great majority was classified as multimodal learners, preferring a variety of presentation modalities. Note the absence of any participants categorized as strictly visual learners.

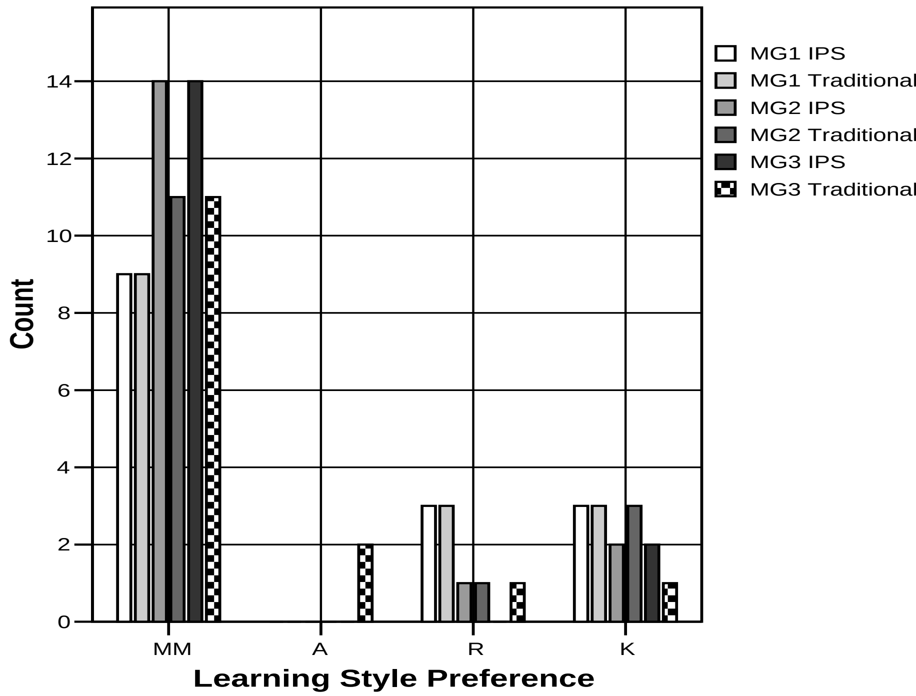


Figure 8. Summary of learning style preference by membership group. (MG = membership group; MM = multimodal learner, A = aural learner, R = read/write learner, K = kinesthetic learner)

The results of the Kruskal-Wallis and Median tests, presented in Tables 10 through 14, show that individual learning style preferences had no statistically significant effect on performance improvements from one EP Knowledge test to another for any membership group, whether in a treatment or control group.

In addition, in order to firmly establish the absence of any relationships between performance gains and learning styles preferences, nonparametric correlations (Spearman's rho) were performed. Table 15 contains the results that revealed no significant relationships. Considering the outcome of these tests, the null hypothesis (H_{03}) was not rejected.

Table 10.

Day 1 Pre-/Posttest: Kruskal-Wallis test statistics for Emergency Procedures Knowledge test change scores with respect to learning style preference.

	Day 1 Pre-/Posttest Treatment Groups			Day 1 Pre-/Posttest Control Groups		
	MG 1	MG 2	MG 3	MG 1	MG 2	MG 3
Chi-Square	4.990	2.865	1.635	2.919	.219	2.869
df	2	2	1	2	2	3
Asymptotic Significance	.083	.239	.201	.232	.896	.412

Note: Grouping Variable: Learning Style Preference; MG = membership group; * p < .05; **p < .01.

Table 11.

Day 1/Day 7 Posttests: Kruskal-Wallis test statistics for Emergency Procedures Knowledge test change scores with respect to learning style preference.

	Day 1/Day 7 Posttests Treatment Groups			Day 1/Day 7 Posttests Control Groups		
	MG 1	MG 2	MG 3	MG 1	MG 2	MG 3
Chi-Square	2.906	.260	.026	2.823	2.608	6.001
df	2	2	1	2	2	3
Asymptotic Significance	.234	.878	.873	.244	.271	.112

Note: Grouping Variable: Learning Style Preference; MG = membership group; * p < .05; **p < .01.

Table 12.

Median test for Emergency Procedures Knowledge test change scores by treatment and control membership groups with respect to learning style preference.

	Treatment Group					Control Group				
	MM	V	A	R	K	MM	V	A	R	K
MG 1										
Day 1 Pre-/Posttest										
> Median	4	0	0	0	2	4	0	0	1	1
<= Median	5	0	0	3	1	5	0	0	2	2
Day 1/Day 7 Posttests										
> Median	3	0	0	2	0	2	0	0	2	2
<= Median	6	0	0	1	3	7	0	0	1	1
MG 2										
Day 1 Pre-/Posttest										
> Median	6	0	0	1	1	2	0	0	0	2
<= Median	8	0	0	0	1	9	0	0	1	1
Day 1/Day 7 Posttests										
> Median	6	0	0	1	1	4	0	0	1	1
<= Median	8	0	0	0	1	7	0	0	0	2
MG 3										
Day 1 Pre-/Posttest										
> Median	8	0	0	0	0	5	0	1	0	0
<= Median	6	0	0	0	2	6	0	1	1	1
Day 1/Day 7 Posttests										
> Median	7	0	0	0	1	5	0	0	1	0
<= Median	7	0	0	0	1	6	0	2	0	1

Note: MG = membership group; MM = multimodal learner; A = aural learner; R = read/write learner; K = kinesthetic learner.

Table 13.

Day 1 Pre-/Posttest: Median test statistics for Emergency Procedures Knowledge test change scores by treatment and control membership groups with respect to learning style preference.

	Day 1 Pre-/Posttest Treatment Groups			Day 1 Pre-/Posttest Control Groups		
	MG 1	MG 2	MG 3	MG 1	MG 2	MG 3
n	15	17	16	15	15	15
Median	.00	.00	22.00	8.00	12.00	44.00
Chi-Square	2.963	1.231	2.286	.185	3.223	1.553
df	2	2	1	2	2	3
Asymptotic Significance	.227	.540	.131	.912	.200	.670

Note: Grouping Variable: Learning Style Preference; MG = membership group; * $p < .05$; ** $p < .01$.

Table 14.

Day 1/Day 7 Posttests: Median test statistics for Emergency Procedure Knowledge test change scores by treatment and control membership groups with respect to learning style preference.

	Day 1/Day 7 Posttests Treatment Groups			Day 1/Day 7 Posttests Control Groups		
	MG 1	MG 2	MG 3	MG 1	MG 2	MG 3
n	15	17	16	15	15	15
Median	.00	-4.00	18.00	.00	12.00	12.00
Chi-Square	3.000	1.231	.000	2.963	1.616	3.636
df	2	2	1	2	2	3
Asymptotic Significance	.223	.540	1.000	.227	.446	.304

Note: Grouping Variable: Learning Style Preference; MG = membership group; * $p < .05$; ** $p < .01$.

Table 15.

Correlations between Emergency Procedures Knowledge test change scores by treatment and control membership groups with respect to learning style preference. (Correlation coefficients / *p*-values)

	Groups	n	Day 1 Pretest / Day 1 Posttest Change Scores	Day 1/ Day 7 Posttest Change Scores
Learning Style Preferences	All MGs	93	-.157 / *p* = .132	.013 / *p* = .904
	All MGs Treatment	48	-.127 / *p* = .389	-.094 / *p* = .526
	All MGs Control	45	-.222 / *p* = .142	-.144 / *p* = .345
	MG 1 Treatment	15	-.101 / *p* = .719	-.145 / *p* = .606
	MG 1 Control	15	-.456 / *p* = .088	.435 / *p* = .105
	MG 2 Treatment	17	.260 / *p* = .314	.126 / *p* = .631
	MG 2 Control	15	.122 / *p* = .664	.273 / *p* = .324
	MG 3 Treatment	16	-.330 / *p* = .212	.041 / *p* = .879
	MG 3 Control	15	-.290 / *p* = .294	-.175 / *p* = .533

Note: MG = membership group; * $p < .05$; ** $p < .01$.

Hypotheses H_{04} and H_{A4}

To test these hypotheses, nonparametric correlation procedures, using Spearman's rho, were performed to measure the relationship, if any, of recall performance (as measured by the scores of the Day 1 and Day 7 Posttests and the change scores from Day 1 to Day 7) and of the treatment groups' subjective assessments of the IPS (from positive to negative). In other words, did the treatment groups' performance and performance changes have an influence on their opinions of the IPS? The results (correlation coefficients and *p* values) of the Spearman's rho correlations are displayed in Table 16. No statistically significant correlations were discovered. The findings support the null hypothesis (H_{04}) and reject the alternative (H_{A4}).

Table 16.
Correlations between subjective assessment categories and Emergency Procedure Knowledge test scores and change scores. (Correlation coefficients / *p*-values)

		Day 1 EP Knowledge Posttest	Day 7 EP Knowledge Posttest	Day 1/ Day 7 Posttest Change Scores
Subjective	MG 1 (n = 15)	-.054 / p = .848	-.256 / p = .356	-.390 / p = .150
Assessment	MG 2 (n = 17)	-.043 / p = .870	.100 / p = .704	.186 / p = .475
Categories	MG 3 (n = 16)	-.158 / p = .559	-.221 / p = .412	-.063 / p = .817

Note: MG = membership group; * $p < .05$; ** $p < .01$.

Hypotheses H_{05} and H_{A5}

In order to address H_{05} and H_{A5} and explore the effect of learning style preferences of the treatment groups on their assessment of the IPS, a crosstabulation of the data was conducted. A crosstabulation displays the number of cases in each category defined by two or more categorical variables. A Pearson's chi-square test measures whether the row and column variables in a crosstabulation are independent of each other (SPSS 12.0). Recall that the learning style preferences can be visual, aural, read/write, kinesthetic, or multimodal. The subjective assessment categories are positive assessment, positive to neutral assessment, neutral assessment, neutral to negative assessment, and negative assessment. Table 17 contains the crosstabulations for each treatment membership group individually and the treatment membership groups in aggregate. Note that graphical representations (Figures O-4 through O-7) of the crosstabulations are available in Appendix O. Table 18 follows the crosstabulation table with each crosstabulation's associated Pearson chi-square test. The results provided evidence that the two variables were independent of each other and hence, learning style preferences had no statistically significant effect on the subjective assessment of the IPS regardless of experience level (membership group), whether examined individually or in aggregate. These findings support that the null hypothesis (H_{05}) is true, and therefore, it was not rejected.

Table 17.
Learning style preference and subjective assessment category crosstabulations.

		Subjective Assessment Categories					
		Positive	Positive to Neutral	Neutral	Neutral to Negative	Negative	Total
MG 1	MM	1	7	0	1	0	9
	V	0	0	0	0	0	0
	A	0	0	0	0	0	0
	R	0	3	0	0	0	3
	K	0	2	0	1	0	3
MG 2	MM	2	12	0	0	0	14
	V	0	0	0	0	0	0
	A	0	0	0	0	0	0
	R	1	0	0	0	0	1
	K	1	1	0	0	0	2
MG 3	MM	11	3	0	0	0	14
	V	0	0	0	0	0	0
	A	0	0	0	0	0	0
	R	0	0	0	0	0	0
	K	1	1	0	0	0	2
All MGs	MM	14	22	0	1	0	37
	V	0	0	0	0	0	0
	A	0	0	0	0	0	0
	R	1	3	0	0	0	4
	K	2	4	0	1	0	7

Note: MG = membership group; MM = multimodal learner; A = aural learner; R = read/write learner; K = kinesthetic learner.

Table 18.
Pearson's chi-square tests resulting from learning style preference and Subjective Assessment Category crosstabulations.

	χ^2	df	Asymptotic Significance (2-sided)
MG 1	2.222	4	.695
MG 2	4.694	2	.096
MG 3	.762	1	.383
All MGs	2.512	4	.642

Note: MG = membership group; * $p < .05$; ** $p < .01$.

Hypotheses H_{06} and H_{A6}

As in the previous question, both variables are categorical variables. As such, a crosstabulation (Table 19) was conducted from which a Pearson's Chi-square test was used to determine whether experience levels, characterized by the membership groups, were independent of the subjective assessment of the IPS based on the categories derived from the Subjective Assessment Survey (Appendix D) scores. The results of the Pearson's chi-square test showed that the two variables were not independent [$\chi^2(4, N = 48) = 20.657, p < .001$]. Cramer's V and the contingency coefficient, nominal symmetric measures of strength and significance of the relationship, indicated that there was a moderately strong, highly significant relationship between the two crosstabulation variables (.464, $p < .001$ and .549, $p < .001$, respectively).

An examination of Tables 19 and 20 clearly shows that the degree of positive assessment is inversely related to the extent of aviation experience. As such, the null hypothesis (H_{06}) is rejected in favor of the alternative (H_{A6}) which submits that experience does have an effect on the subjective assessment of the IPS.

Table 19.
Membership group and subjective assessment category crosstabulation.

	Subjective Assessment Categories					Total
	Positive	Positive to Neutral	Neutral	Neutral to Negative	Negative	
MG 1	1	12	0	2	0	15
MG 2	4	13	0	0	0	17
MG 3	12	4	0	0	0	16

Note: MG = membership group.

Table 20.
Subjective assessment raw scores descriptive statistics.

Membership Group	Mean*	N	Std. Deviation	Min	Max
MG 1	35.13	15	5.680	23	45
MG 2	28.76	17	6.638	16	40
MG 3	23.69	16	6.681	14	36

Note: * The lower the score mean, the more positively inclined the assessment; MG = membership group; min = minimum; max = maximum.

Hypotheses H_{07} and H_{A7}

The hypotheses of whether the IPS was assessed positively by the majority of those in the treatment groups as a useful pictorial mnemonic for remembering aviation emergency procedures was answered through the following descriptive statistics. Even though significant differences were found in IPS assessments depending on aviator experience (H_{A6}), the overwhelming majority, nearly 96% of the treatment population, rated the IPS in a positive manner (above neutral and as classified using the scoring procedures outlined in Appendix E). Table 21 contains the overall frequency of assessment ratings, while Figure 9 presents the assessment ratings by sample population percentages. These findings provide that the alternative hypothesis (H_{A7}) is accepted as true and, thus, refute the null hypothesis (H_{07}).

Table 21.
Frequency of overall IPS ratings.

Assessment	Frequency
Positive	17
Positive to Neutral	29
Neutral	0
Neutral to Negative	2
Negative	0
Total	48

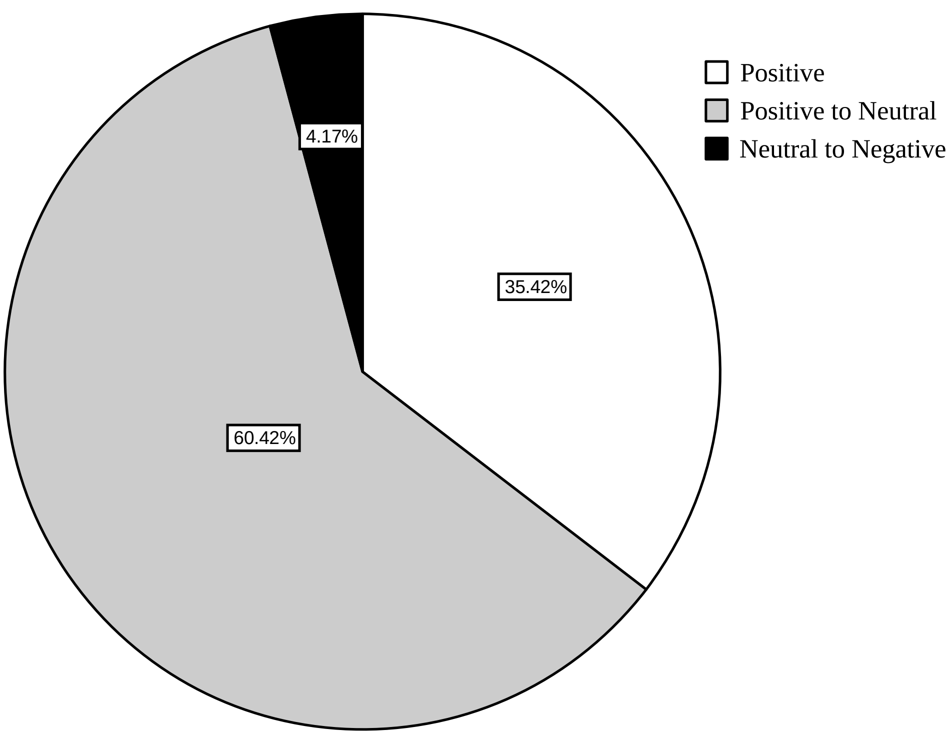


Figure 9. Sample population percentages of overall IPS ratings by category.

To achieve a more substantive and insightful understanding of the IPS assessments, an examination of the unprocessed responses to each question is useful. Table 22 provides the frequency of responses per abbreviated survey statement. A review of the responses demonstrates the IPS was, by and large, favorably appraised.

Table 22.
Subjective assessment responses per survey statement.

Abbreviated Assessment Statements	Subjective Assessment Categories				
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. IPS not a useful tool.	14	21	2	11	0
2. Prefer my own system over IPS.	5	15	26	2	0
3. I would not use IPS in the future.	9	26	6	5	2
4. IPS adds to the educational burden.	11	29	5	3	0
5. IPS symbols not intuitive.	17	23	3	5	0
6. IPS too complex for new student.	18	29	1	0	0
7. IPS has not improved EP recall.	8	23	12	5	0
8. Don't teach IPS to future students.	18	22	8	0	0
9. IPS did not assist me.	7	24	12	5	0
10. IPS is a waste of valuable time.	10	31	6	1	0
11. Would not recommend IPS to the Army.	14	27	6	1	0
12. IPS may confuse pilot majority.	11	32	4	1	0
13. IPS should not be used in EP checklist instead of text.	10	14	16	6	1
14. IPS could cause confusion during actual emergency situation.	11	23	10	4	0

Finally, the Subjective Assessment Survey (Appendix D) solicited from participants additional comments regarding the IPS, the intuitiveness of the symbols, and recommendations for future applications. Thirty-two of the 48 treatment participants provided additional comments which are located in Appendix P. A review of the remarks indicated that 50% (16) were laudatory in nature; 25% (8) recommended specific symbol changes; 15.6% (5) were laudatory of the IPS, yet negatively critical of some of the symbols; and 9.4% (3) were negatively critical of the IPS as a mnemonic system, citing the possibility of causing confusion and/or misinterpretation.

Hypotheses H_{08} and H_{A8}

The testing of Hypotheses H_{08} and H_{A8} sought to resolve whether the symbols that make up the IPS were easily recognized (intuitive) and, thus, remembered (having memorable qualities). To answer the question, paired samples *t* tests were used to compare the means of the Symbol Recognition Tests (Appendix F) administered on Days 1 and 7. Table 23 presents descriptive statistics for the Day 1 and Day 7 Symbol Recognition Tests for each membership group and all membership groups combined.

Recall that the Day 1 test was administered immediately following the participants' introduction to the IPS symbols. Taking into account the very limited exposure to the symbols (less than 30 minutes) prior to the test, each group scored, on average, at least 75% correctly (Figure 10), with 22.9% of the sample population achieving a perfect score.

Table 23.
Symbol Recognition test score descriptive statistics.

	Membership Group	n	Mean	Std. Deviation	Std. Error Mean	Min	Max
Day 1 Symbol Recognition Test	MG 1	15	85.00	16.366	4.226	45	100
	MG 2	17	92.35	8.314	2.016	75	100
	MG 3	16	75.31	13.350	3.338	40	95
	All MGs	48	84.38	14.536	2.098	40	100
Day 7 Symbol Recognition Test	MG 1	15	85.00	11.802	4.226	60	100
	MG 2	17	81.18	15.765	3.824	45	100
	MG 3	16	85.00	12.383	3.096	55	100
	All MGs	48	83.65	13.358	1.928	45	100

Note: MG = membership group; min = minimum; max = maximum.

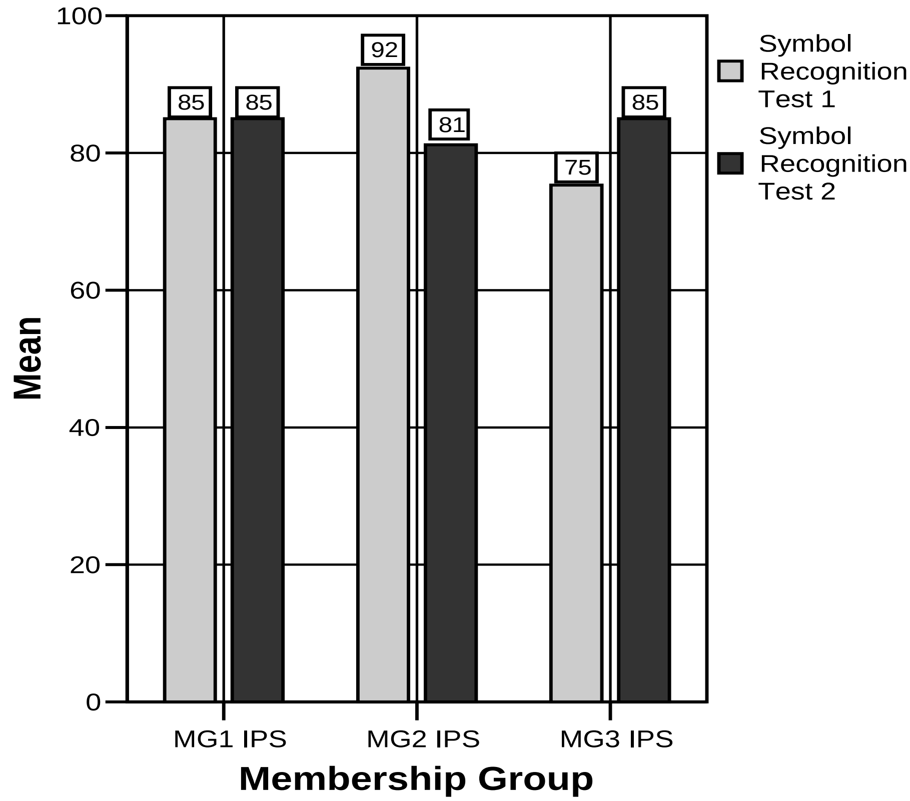


Figure 10. Symbol Recognition Test score means by membership group. (MG = membership group)

When tested as a collective body, the participants' symbol recognition scores did not differ significantly [$t(47) = .290$, $p = .773$] from one week ($M = 84.38$) to the next ($M = 83.65$). Similar results were achieved when comparisons of the MG 1 (highly-experienced) Day 1 and Day 7 test scores ($M = 85.00$ and $M = 85.00$, respectively) were conducted. Obviously, since the values were the same, the paired samples tests for MG 1 showed no statistically significant performance differences between the two tests [$t(14) = .000$, $p = 1.000$].

In contrast, the minimally-experienced (MG 2) and naïve (MG 3) groups showed significant differences in their test performances from Day 1 to Day 7, albeit in different directions. The paired samples test for MG 2 showed a statistically significant decline in performance from one week ($M = 92.35$) to the next ($M = 81.18$) [$t(16) = 3.297$, $p = .005$]. MG 3, on the other hand, demonstrated a statistically significant [$t(15) = -3.183$, $p = .006$] improvement in their test performance from Day 1 to Day 7 (from $M = 75.31$ to $M = 85.00$).

It is important to realize that the minimally-experienced group (MG 2) showed a decline from an average score on the first test that was seven points *higher* than the highly-experienced group (MG 1) (92% vs. 85%, respectively) to a score one week later that was just four points *lower* the highly-experienced group (81% vs. 85%). Also note that the naïve group (MG 3) achieved the same level of symbol recognition on Day 7 as the highly experienced group (both with 85% scores). The importance of these observations is that on both tests, the average of the least-experienced participants (MG 2 and MG 3) scored nearly the same or better than the

highly-experienced group (MG 1), who have a minimum of four years experience and familiarity memorizing the emergency procedures by text. The performance of the less experienced groups, especially the naïve group, in closely matching the highly-experienced group demonstrates the ability of the symbols to bring back uncommon text for which there was minimal or no familiarization.

For the treatment group as a whole and for the highly-experienced group (MG 1) individually, support was for the null hypothesis (H_{08}) as being true and indications are that recall of the symbols was maintained without any significant change. Conversely, the significant differences in performance for the minimally-experienced (MG 2) and naïve (MG 3) groups lend support for the alternative hypothesis (H_{A8}). Notwithstanding the performance decrement of MG 2 to levels nearly the same as the other groups, the maintenance or improvement in IPS symbol recall by the majority of participants provides encouraging evidence as to the intuitive nature and memorable qualities of the IPS.

Hypotheses H_{09} and H_{A9}

Hypotheses H_{09} and H_{A9} were tested to uncover any possible associations between the time from Day 1 to Day 7 committed to study and the performance gains on the EP Knowledge and Symbol Recognition posttests. The Study Experience Report (Appendix J) was used to collect data from which descriptive statistics were derived and possible relationships between committed study time and test results were explored. Boxplots of individual group data were examined to identify gross outliers. The boxplot (Figure 11) of the data of the minimally-experienced control group (MG 2) revealed the presence of three gross outliers greater than five standard deviations from the mean. It is possible that the presence of these outliers may have resulted from the misinterpretation of the data collection instructions by these individuals. The three outliers were normalized (replaced with the mean of the remaining minimally-experienced group members) prior to analysis. In addition to time committed to the overall study of emergency procedures, members of the treatment groups were also requested to provide an estimate of their time using the IPS while studying.

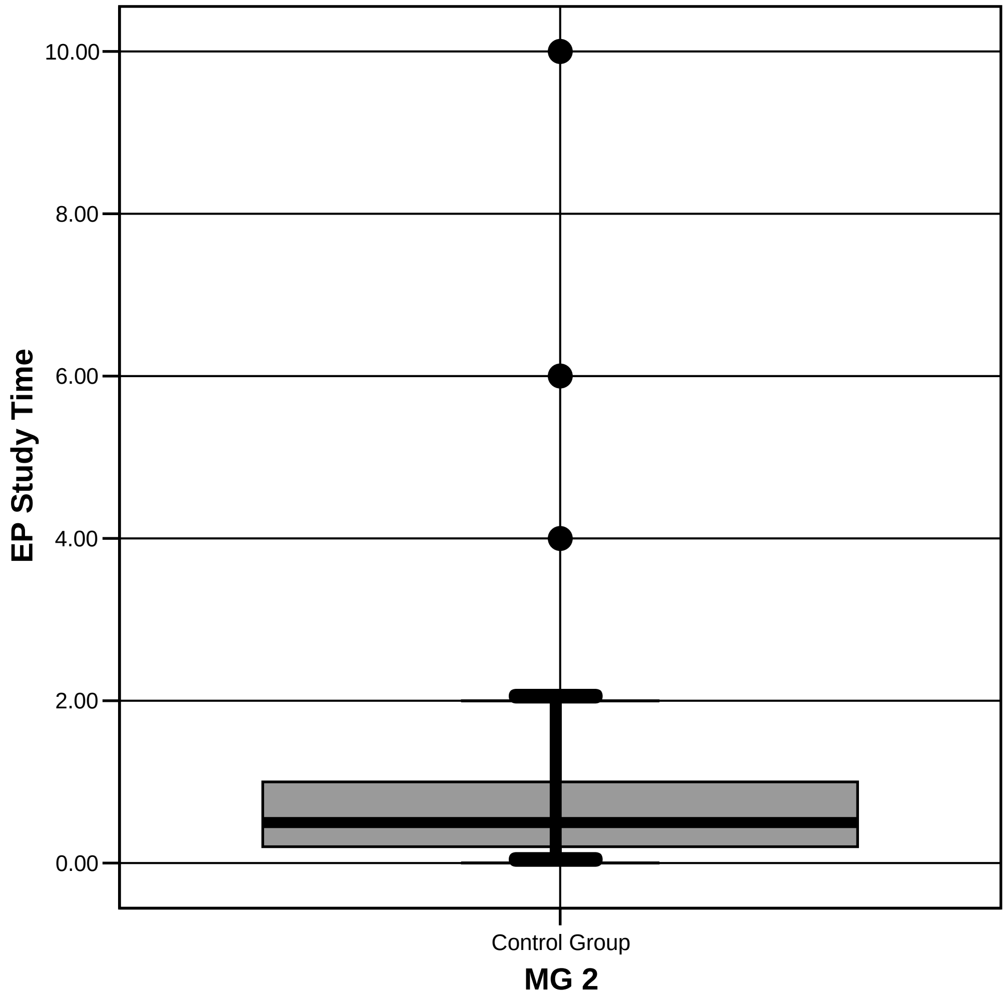


Figure 11. Boxplot of minimally-experienced control group's study time. (EP = emergency procedure; MG = membership group)

An examination of the descriptive statistics (Table 24) shows that in almost every case (the naïve treatment group using IPS being the only exception), the control groups reported a greater daily average time studying than the treatment groups. The results of Kruskal-Wallis and Median tests (Tables 25 through 27) indicated no significant differences in study time by treatment group members when using the IPS. On the other hand, a significant group difference was detected in the study time when studying without the IPS. Naturally, this population included treatment and control group members. The significance was due to the fact that all 15 members of the minimally-experienced control group (in bold, Table 26) studied significantly more than the median time of the overall group population. There seems no reasonable explanation for this randomly assigned group's extraordinary penchant for studying other than chance.

Table 24.
Study time descriptive statistics (hours per day).

	Membership Group	Treatment/ Control	Mean	N	Std. Deviation	Min	Max
Estimate of time studying EPs without IPS (Estimate of time using IPS to study EPs)	MG 1	Treatment	.3667 (.2867)	15	.56779 (.54231)	.00 (.00)	2.00 (2.00)
		Control	.4500	15	.60622	.00	2.00
	MG 2	Treatment	.3353 (.2765)	17	.53379 (.54946)	.00 (.00)	2.00 (2.00)
		Control*	.9967	15	.51077	.25	2.00
	MG 3	Treatment	.2438 (.2906)	16	.22721 (.30233)	.00 (.00)	1.00 (1.00)
		Control	.2900	15	.29000	.10	1.00

Note: *Outliers normalized; MG = membership group; EP = emergency procedures; IPS = Intuitive Pictorial System; min = minimum; max = maximum.

Table 25.
Kruskal-Wallis test statistics for reported emergency procedures study time.

	EP Study Time Without IPS Treatment & Control Groups	EP Study Time Using IPS Treatment Groups only
Chi-Square	23.426	4.790
df	5	2
Asymptotic Significance	.000**	.091

Note: Grouping Variable: Membership Group; * $p < .05$; ** $p < .01$; EP = emergency procedures; IPS = Intuitive Pictorial System.

Table 26.
Median test for reported emergency procedures study time.

		Treatment Groups			Control Groups		
		MG 1	MG 2	MG 3	MG 1	MG 2	MG 3
EP Study Time without using IPS	> Median	6	4	6	7	**15**	6
	<= Median	9	13	10	8	**0**	9
EP Study Time using IPS	> Median	6	4	10	*	*	*
	<= Median	9	11	6	*	*	*

Note: * Control Groups were not exposed to IPS (Intuitive Pictorial System);
MG = membership group; EP = emergency procedures.

Table 27.
Median test statistics for reported emergency procedures study time.

	EP Study Time without IPS Treatment & Control Groups	EP Study Time using IPS Treatment Group only
n	93	48
Median	.2000	.1000
Chi-Square	21.826	2.756
df	5	2
Asymptotic Significance	.001**	.252

Note: Grouping Variable: Membership Group; * p < .05; **p < .01; EP = emergency procedures; IPS = Intuitive Pictorial System.

The results of a series of Spearman's rho correlations revealed that only two statistically significant relationships existed between the reported study times and participant performance. The significant correlations were found relevant to the highly-experienced (MG 1) treatment group only. The tests found that there were significant positive correlations between participant study time using the IPS and improvements (as evidenced by change scores) in both the EP Knowledge and Symbol Recognition tests [$r_s(13) = .523$, $p = .045$ and $r_s(13) = 529$, $p = .043$, respectively]. Stated clearly, as the members of the MG 1 treatment group's one-week study time increased, so did the improvements in their test scores.

Hence, with regard to the highly-experienced MG 1 group, there was a significant association between committed study time during the week and test performance gains. These findings refute the null hypothesis (H_{09}) and support the alternative (H_{A9}). Even though the minimally-experienced (MG 2) group studied significantly more than the other groups, there was no significant correlation between study time and performance gains. Similarly, there was no correlation revealed regarding the naïve (MG 3) group either. Thus, for these two groups, the null hypothesis was true.

Discussion and Implications of the Research

The primary purpose of this study was to determine the utility and merit of using the IPS as a mnemonic strategy to facilitate the learning and accurate recall of aviation emergency procedures. The research methodology used data from three distinct membership groups based on their levels of aviation experience. As such, each group provides unique insights into the assessment, utility, and merit of the IPS. The following discussion attempts to highlight these sometimes subtle insights.

Research Question 1

The results of the statistical tests conducted to answer RQ1 determined that the IPS did not improve retention and recall in the overall sample population over that of the traditional method from Day 1 EP Knowledge Pretest to Day 1 Posttest. In light of previous research extolling the ease and capacity for remembering pictorial representations (Haber, 1970; Standing, Conezio, and Haber, 1970; Potter, 1976; Simons, 1996; Hollingworth, Williams, and Henderson, 2001; Hollingworth and Henderson, 2002), this finding was unexpected. Moreover, the control group of the total sample population achieved a statistically significant improvement in their scores. This finding, taken in isolation, would indicate a clear superiority of the traditional method over the IPS method. However, the comparative results (discussed below) of the Day 1 to Day 7 Posttests are inconsistent with the above observation and, thus, do not support this preliminary conclusion. The initial large disparity between group performances was initially puzzling; however, a plausible explanation for the disparity may be the difference in the amount of information presented to each group.

It is important to note that the Day 1 EP Knowledge Posttest was administered immediately following the EP Instructional PowerPoint Presentation (Appendices G or H, as appropriate) and that two-thirds of the total sample population (MG 1 and MG 2) had previous memorization experience with the EPs. Thus, the EP Instructional PowerPoint Presentation

served the majority of the control group as a review and reinforcement of existing/established memory strategies. In contrast, those in the treatment group were presented with the same EPs, plus, were directed to employ a new memorization strategy as their memorization technique. The 30-minutes to one-hour interval between Day 1 EP Knowledge Pretest and Posttest may not have been sufficient time to assimilate the amount of new information presented.

The plausibility of the explanation is supported when the Day 1 and Day 7 Posttests are compared and the results are inconsistent with the findings above. In this comparison, the average score improvements made by the sample population's treatment and control groups did not differ significantly from each other. With regard to the research question, the IPS still did not improve retention and recall over that of the traditional method in the overall population; however, neither method was significantly superior to the other. What is more, participants receiving either method of instruction made statistically significant improvements, on average, in their EP Knowledge posttest performances from Day 1 to Day 7. All things considered, neither instructional method demonstrated conclusive superiority over the other.

Research Question 2

In determining if there was a difference in recall performance between the IPS and traditional methods with regard to experience levels, the statistics revealed that significant differences in performance were indeed influenced by experience levels with the only difference appearing in the minimally-experienced population (MG 2).

Not unexpectedly, neither training method had an affect on the performance of the highly-experienced group (MG 1) who showed no significant improvements in any of their tests. As noted earlier, this may be due to a ceiling effect. In other words, participants of this group started with relatively high Pretest scores which then remained high on their two posttests.

As in the case with the highly-experienced group, the training method made no significant difference in the performance improvements of the naïve group (MG 3) as both treatment and control groups made significant gains in their performances. Of interest is that from the Day 1 Pretest to Day 1 Posttest, the control group made the greatest average improvement (41 vs. 22 points). But, from the Day 1 to Day 7 Posttest, it was the treatment group who made the greatest average improvement (21 vs. 10 points). Again, as discussed with reference to RQ1, the difference between Day 1 and Day 7 Posttest performances of the treatment and control groups in this naïve population may be due to the difference in the amount of new information presented to each group on Day 1.

The significant difference between instructional methods referred to above was detected in the minimally-experienced group (MG 2). The Median test for this group illustrates no practical differences between treatment and control groups for the performance improvements from Day 1 Pretest to Day 1 Posttest, but does show differences in group performances from Day 1 to Day 7. Furthermore, it was the control group that performed better (an 11 point average improvement), while the treatment group's average score decreased by 3 points. These findings should point conclusively to the superiority of the traditional method over the IPS with regard to minimally-experienced aviators. However, the findings are confounded by the potential effects

of the disproportionate study time reported by the two groups (treatment and control) discussed later in Research Question 9. Because the sample population was actively engaged in some capacity in the U.S. Army's flight school program as instructors, active students, or inactive students, and not subjected to a completely controlled laboratory environment, study time could not be regulated or controlled. Consequently, members of the minimally-experienced control group (MG 2) reportedly studied on average three times as long as the treatment group (.996 vs. .335 hours per day; Table 22), the largest significant difference within a membership group. Therefore, as with RQ1, the findings do not show the clear superiority of either method.

Research Question 3

To answer this question, the VARK Questionnaire (Appendix C) was employed to classify participants' learning style preferences. It was used for pragmatic reasons: it is quick and easy to complete and the results are relatively easy to obtain and interpret. Using the derived classifications, Kruskal-Wallis and Median tests were employed to determine if recall performance (as measured by gains in the EP Knowledge tests) between the IPS and traditional methods varied with respect to learning style preferences. The results produced no statistically significant differences.

According to theory, individuals differ in the manner from which they best absorb information (Harrison, Andrews, and Saklofske, 2003; Cassidy and Eachus, 2000; Dunn, 1983) based largely on the preferred learning modality (Zapalska and Dabb, 2002). Specifically, those with style preferences should show the greatest ability to recall material presented in that manner (Krätzig and Arbuthnott, 2006). This study's sample population was comprised of very few members having a single learning style preference (Figure 8) with the majority (68 of 93) classified as having multimodal learning preferences. Despite reports praising the virtues of matching learning style preference with modality of presentation (Munro and Rice-Munro, 2004; Farkas, 2003; Lohri-Posey, 2003), this study's findings are consistent with those of Loo (2004) and Krätzig and Arbuthnott, who report weak to no significant link between learning style preference and objective memory performance. In any case, the findings, at least in this sample population, indicate that neither the IPS nor the traditional training method is prejudicial toward any single or multimodal learning style preferences.

Research Question 4

According to the Instructor Pilot Handbook (U.S. Army Aviation Center, 2000), the *Principle of Effect* states that learning is strengthened when accompanied by a pleasant or satisfying feeling. Conversely, learning experiences that produce feelings of frustration, confusion, and futility weaken learning. The aim of Research Question 4 was to achieve a sense for the emotional effect of the IPS on the treated membership groups. Basically, the question asked if participants' performances and performance gains had any correlation to the manner in which they assessed the IPS. Since no statistically significant correlations were found between recall performance and the subjective assessment of the IPS, no inferences or presumptions of training effect, either positive or negative, can be made based upon the relationship of these two variables.

Research Question 5

Research Question 5 was an inquiry into the possibility that learning style preference might predispose one's subjective assessment of the IPS. Stated differently, the goal was to determine if those more likely to prefer learning in other than visual ways might have a less positive opinion of the IPS than visually-oriented learners. A crosstabulation (Table 17) of the variables produced no significant chi-square statistics (Table 18) for any of the membership groups or all membership groups in aggregate. This means that the two variables (learning style preference and subjective assessment categories) were independent and unrelated and operationally, that learning style preference has no affect on one's opinion of the IPS as a mnemonic strategy.

Although not significant, it is interesting to note that the only two members to rate the IPS in a *neutral to negative* manner were two highly-experienced aviators: one, a kinesthetic learner, and the other, a multimodal learner (Table 17). A closer examination of the composite data revealed that the kinesthetic learner performed poorly on the EP Knowledge pretest and both posttests (20, 15, and 24 points below the mean, respectively). The multimodal learner, on the other hand, achieved performance scores closely aligned with group means. These observations are of questionable importance, but may provide some additional insight.

Research Question 6

To determine if experience levels had an effect on the subjective assessment of the IPS, a crosstabultion of the two variables was performed. The resulting chi-square statistic identifies a moderately strong, highly significant relationship ($p < .001$) between the two variables. This indicates that experience does have an affect on the subjective assessment of the IPS. Simply put, the more experience, the less favorable the assessment. That being said and as revealed above, the IPS received only two assessments that were negatively inclined, both by members of the highly-experienced group. Even though all other assessments were slanted in a positive direction, the significant relationship between experience and subjective assessment is evident in the crosstabulation in Table 19. It is also apparent in a comparison of the group means in Table 20. In the case of subjective assessment scores, the lower the score, the more positive the assessment. The highly-experienced group's mean was 35.13, with the minimally-experienced group at 28.76, and the naïve group at 23.69.

A reasonable explanation for the significant relationship may be based on a common resistance towards change. According to the expectancy theory (Lines, quoting Vroom, 2004), "people consciously choose courses of action, based upon perceptions, attitudes, and beliefs, as a consequence of their desires to enhance pleasure and avoid pain" (p. 198). Expectancy theory predicts that resistance will occur if 1) the individual has expectancies that the relationship between a change in behavior and performance is uncertain, 2) the link between performance and outcome is uncertain, and 3) the outcomes have negative value to the individual (Hope and Pate, 1988).

Experience in aviation implies learned and established knowledge and skills. Once established, any alterations or redefinitions naturally lead to some people feeling uncomfortable

or threatened (Walley, 1995). Aviators, being professional people, value their professionalism and hard-won skills. Any changes that threaten to make these skills obsolete are likely to encounter resistance, especially with a less technically competent aviator who may become defensive to preserve a competent self-image (Jensen, 1998). In addition, unfamiliar novel systems, such as the IPS, provoke barriers to change such as fear of the unknown, low trust, arrogant attitudes, and resistant organizational cultures (Kane and Darling, 2002). In light of the preceding discussion, the discovery that experience levels affect the assessment of the IPS is logical and not unexpected.

Research Question 7

Based on the descriptive statistics derived from the Subjective Assessment Surveys (Appendix D), answering whether the IPS was appraised as a useful mnemonic for the intended purpose was straightforward and unproblematic. As stated in the previous chapter, 96% of the sample population rated the system in a favorable manner. Support for incorporating the IPS into flight training was evidenced by noting that only one of the participants would not recommend the system for use in the U.S. Army. No respondent felt that the IPS was too complex for new flight students and none recommended that it not be taught to future flight students. These findings support previous research, such as conducted by Haber (1970) and Cherry, Dokey, Reese, and Brigman (2003), which demonstrated peoples' predilection for pictorial representations and their usefulness as aids to memory.

Research Question 8

Along with the results of the Subjective Assessment Survey, the findings relating to this research question may be the single most important indication of the merits and utility of the IPS as an aid to memory. The intent of this research question was to determine if the IPS symbols were easily recognized (intuitive) and, thus, had memorable qualities. Since the first Symbol Recognition test (Appendix F) was administered within 30 minutes of the participants ever seeing the symbols, a mean score of 84.38 for the sample population was impressive and indicative of the symbols' intuitive nature and memorability. The fact that every experience group averaged high scores immediately following their initial presentation showed the symbols to be intuitive regardless of prior knowledge and familiarity with the represented terms.

When the test was administered one week later, the mean score for the sample population had not changed significantly (to 83.65). When each experience group was examined closely, the highly-experienced group's mean performance showed no change (85 vs. 85). The naïve group showed a significant performance improvement over the one week period (from a mean of 75 to 85), while the minimally-experienced group showed an average decline in performance from 92 to 81. Although a significant fall off, an 81% correct score, on average, by the minimally-experienced group still demonstrates strong and successful recall of the symbols nearly equivalent with that of the highly-experienced group. The test results and comparisons suggest strongly that the symbols are indeed intuitive and memorable.

Although performance on the Symbol Recognition tests is a good indication of the intuitiveness of the current symbols, written comments received via the Subjective Assessment

Survey will aid in refining the symbols to enhance intuitiveness and eliminate any possibilities of confusion or misinterpretations.

Research Question 9

Analysis of study time data revealed that the minimally-experienced (MG 2) control group studied far more than the other groups (greater than twice as long) and that significant correlations existed in the highly-experienced treatment group's study time and performance gains. Although these findings were statistically significant and noteworthy, their importance is not clear.

As discussed earlier in Research Question 2, the significant difference in the MG 2 control group's study time compared to the treatment group's may have played a role in the results that showed that, in that experience level, the traditional method produced significantly better results over the IPS. Regarding the significant correlations between study time and performance gains by members of the highly-experienced treatment group, all members of this group happened to be instructor pilots. According to Estrada and Dumond (2006), instructor pilots study emergency procedures less frequently than graduate and student pilots. It is likely that instructor pilots rely on their daily instructional activities to maintain a minimal level of recall proficiency. Therefore, any small increase in the amount of time committed to studying emergency procedures would naturally result in an increase in their recall performance.

Summary of the Findings

Table 28 serves to summarize the findings of this research effort and is useful in constructing a comprehensive interpretation of the results.

Table 28.
Findings summary.

Research Question/Answer	Tests Used	Results (N.S. = not significant)
1. Did IPS improve retention/recall over traditional method in the overall population?	Between Methods: EP Knowledge D1 Pre to D1 Post	Significant difference: Traditional method superior.
No, but no different from traditional from Day 1 Posttest to Day 7 Posttest.	EP Knowledge D1 Post to D7 Post	N.S.
	Within Methods: EP Knowledge D1 Post to D7 Post	Both methods showed significant performance gains.

Note: D = Day; EP = emergency procedures; MG = membership group.

Table 28 (continued).
Findings summary.

Research Questions/Answers	Tests Used	Results (N.S. = not significant)
2. Is there a difference in performance between the traditional and using the IPS methods with respect to experience levels? Yes.	EP Knowledge D1 Pre to D1 Post EP Knowledge D1 Post to D7 Post	MG 3 treatment and control groups' performance gains sig. diff. than other groups, but no method superior. MG 2 control group and MG 3 treatment/control groups' performance gains sig. diff. than other groups, but IPS not clearly superior.
3. Did learning style preference (LSP) affect performance? No.	EP Knowledge D1 Pre to D1 Post / LSP Questionnaire EP Knowledge D1 Post to D7 Post / LSP Questionnaire	N.S. N.S.
4. Did performance affect subjective assessment (SA) of IPS? No correlation found.	EP Knowledge D1 Post / SA Survey EP Knowledge D7 Post / SA Survey EP Knowledge D1 to D7 Post / SA Survey	N.S. N.S. N.S.
5. Did learning style preference affect subjective assessment of IPS? No correlation found.	LSP / SA Survey	N.S.
6. Does experience affect subjective assessment? Yes. Degree of positive assessment is inversely related to amount of experience.	Membership Group / SA Survey	Significant differences in assessments of IPS with regard to experience levels.

Note: D = Day; EP = emergency procedures; MG = membership group.

Table 28 (continued).
Findings summary.

Research Question/Answer	Tests Used	Results (N.S. = not significant)
7. Is IPS positively assessed by the majority of participants? Yes. Overall positive assessment by majority.	SA Survey	96% rate IPS in a positively-inclined manner.
8. Are the IPS symbols intuitive and memorable? Yes.	Symbol Recognition D1 to D7 Posttests	Average of the least-experienced participants (MG 2 and MG 3) scored nearly the same or better than the highly-experienced group (MG 1).
9. Is there an association between study time and performance? Yes, but for MG 1 only.	Study Experience Report / EP Knowledge & Symbol Recognition D7 Posttests	Significant difference: MG 1 treatment and control groups' study time has significant correlation with performance gains. Note: MG 2 control group studies significantly more (3x) than all other groups.

Note: D = Day; EP = emergency procedures; MG = membership group.

Limitations

Study population

The following discussion is based on the observations of the researcher and may provide useful insights into the limitations of using this study population to assess training methods. Aviators are professionals who are proud, egotistical, and defensive of their knowledge and skills. Hence, it was apparent during the recruitment of participants that there was a general aversion to tests that might challenge or question their knowledge. This was especially true of the highly-experienced pilots who were particularly reluctant to participate in the study when they learned of the testing details. The minimally-experienced pilots were similarly reluctant, but not to the degree of the more experienced pilots. Those in the minimally-experienced group seemed to have hopes of some potential benefit from the experience, whereas, the highly-experienced saw little or no benefit from participation. On the other hand, the naïve population awaiting the start of flight school was eager to take part in the study. It was clear that they perceived no threat to their aviator status (since they did not have one) and that there was great potential for personal benefit from their experience. It may be because of this seeming threat to status and the perceived potential for individual benefit that there were palpable differences between experience groups and individuals in their motivation to support the research effort.

In addition, flying helicopters, whether teaching or learning, is a very demanding enterprise. Obviously, anything relating to the successful accomplishment of flight school-related tasks or duties took priority over the voluntary participation in this research project. Thus, varying degrees of commitment to the research project and to learning and using the IPS symbols were observed. This variation in commitment was corroborated by the occasional difficulty in scheduling the follow-on (Day 7) testing.

The highly-experienced group was witnessed (through verbal comments to the researcher and to each other) to be especially partial to their own memorization techniques. This may have negatively influenced their commitment to adding the IPS as a mnemonic strategy fearing interference with their own systems. This is quite understandable since members have years of successful experience using their own strategies.

<u>Length of study period</u>

Due to limited resources in time and funding, the study was designed to measure the performance gains of at least ninety participants over a one week period. Since memorization strategies such as the IPS are used to enhance long term memory, longitudinal studies over much longer periods may provide a much clearer, substantive depiction of the effectiveness of the IPS compared to that of the tradition method.

<u>Control of participant study time</u>

As mentioned several times previously, due to participant circumstances (involvement in Army flight school), the amount of participant study time could not be manipulated (mandated, limited, or controlled) in any way by the researcher. Each group member was encouraged to study their emergency procedures using their assigned method, and study time data was collected which showed that study time sometimes varied by group assignment. As in any academic environment, time committed to study will vary with each individual as it did in this research effort. Although unfavorable to the experimental research effort, the variability of study time may have produced findings that are more representative of what might be experienced in the real world applications of these methods. That is, average study time varies from one group to the next.

<u>Ceiling effect</u>

Regarding the performance of the highly-experienced membership group, it is possible that treatment effects on knowledge performance were obscured by a ceiling effect caused by the level of preexisting knowledge (the dependent variable) of this group.

Study implications

This research examined the utility and merit of a novel system of intuitive pictures (the Intuitive Pictorial System or IPS) taught as a mnemonic strategy to facilitate learning and accurate recall of complex emergency procedures. Much research has been conducted (Chapter 3) on visual memory and memorization strategies; however, a review of the literature found no

evidence of any attempts to introduce any structured, formal mnemonic strategy system to the learning of Army aviation emergency procedures. It is hoped that these findings will contribute to the body of knowledge and provide important information about the practical application of a pictorial memorization strategy from which informed resource allocation decisions can be made.

The positive results of the Subjective Assessment surveys and Symbol Recognition tests indicated the popularity, intuitiveness, and memorability of the prototype symbols. Information from this research can provide guidance on the refinement and integration of a pictorial system or systems which could augment textual emergency procedures and abbreviate checklists and aviation cockpit instrumentation. This information could lead to important innovations to current U.S. Army teaching techniques and minimize the use of random memorization techniques by students. Applications of a pictorial system representing common aviation procedures could be of benefit to the other military services and the national and international civil aviation communities in much the same way as international highway signs have become. A standardized pictorial system of aviation procedures may not just benefit individual graduate and student pilots, but could be a valuable contribution to aviation safety.

Conclusions

The goal of this research project was to determine the utility and merit of a novel system of intuitive pictures (the IPS) taught as a mnemonic strategy to facilitate the learning and accurate recall of complex aviation emergency procedures. Although the study's findings did not show that the IPS produced performance gains superior to that of the traditional method, the findings did demonstrate the utility and merit of the system as an augmentation to traditional textual procedures. This was evidenced by user assessments, user comments, and symbol recognition test performance. The manner in which the symbols were able to facilitate the recall of uncommon, unfamiliar terms and phrases in a naïve population to a level comparable to that of highly-experienced pilots in just one week, highlights the potential for such a mnemonic strategy to aid in the encoding of information into long-term memory. The promise in incorporating a refined IPS into the U.S. Army flight educational program would be in reducing the expense and time it takes to teach, learn, and maintain complex aviation emergency procedures, thus, enhancing aviation safety and preserving vital resources.

Suggestions for future research

The objective findings of this study did not achieve the clear results of previous research which reported that pictorial mnemonics lead to benefits beyond simple rote memory (Carney and Levin, 2003; Cherry, Dokey, Reese, and Brigman, 2003). The limitations outlined above may have unintentionally masked or suppressed the objective measures when comparing the IPS to the traditional training method. Research is needed which provides for a more definitive assessment of the IPS's capacity to improve the long-term memory of aviators for emergency procedures. Future research should employ designs which contend with the cited limitations and should attempt to validate the findings of this research effort using other designs capable of strengthening construct validity.

A course for improving the strength and certitude of this study's conclusions regarding the IPS's effectiveness would be to focus the research on a naïve group over a much longer period of time. In all likelihood, a naïve population would provide the best indicators of training method effectiveness because, as observations during this study revealed, populations with previous experience also possess biases and motivational issues that are difficult to control, influence, and/or overcome. A naïve population seems to possess an initial willingness to learn in the manner in which the material is presented and would therefore, provide a clearer, more objective indication of method effectiveness. By extending the study period over a longer period of time (six months to several years), the effectiveness of each method for maintaining or improving aviators' long-term memory for emergency procedures could be decisively determined.

That said, it is suggested that a future study be conducted which randomly assigns at least six classes of 20 new flight students to receive either the IPS or traditional EP training method. As the students progress through the required EP training, their retention of the EPs would be tested at three-week intervals until the completion of flight school 36-weeks later, thus, providing 12 observations. Comparisons of IPS and traditionally-trained performances over this extended period would provide a better indicator of differences in training method effectiveness, thus strengthening internal and external validity. The methodology outlined above would provide the foundation for a longitudinal study which could remain ongoing for a number of years. Upon graduation, aviators are easily tracked from posting to posting. Follow-on data collection (memory tests and surveys via personal or internet interview) would provide valuable information as to the capacity of each training method to enhance long-term memory and recall accuracy.

It is unreasonable to expect the administrators of the Army's flight training program to allow the control (by mandate or restriction) of the time flight students spend studying EPs. Therefore, in order to provide analysis of study time effects, it is recommended that study time be recorded as reported by each participant. At the completion of the data collection, participants of the IPS and traditional groups would be matched or paired by specific study time or study time periods (as in, 0–1 hour per week, 2–4 hours per week, etc.) and comparisons made with study time as the factor. Conceivably, this approach will yield the effects, differences, and/or associations of study time, training method, and recall ability over the much longer data collection period. Finally, should future research involve participants of different experience levels, the design should remove the potential for ceiling effects by making the experimental tasks much more difficult than posed in this study, especially for the highly-experienced group.

Further research into mnemonic strategies in the aviation context should not be limited to that of the assessment of the IPS. Advances in technology, cockpit displays, and computer-generated human interfaces are changing the manner in which the military pilot interacts with the aircraft. These advances often create new operational requirements which increase the pilot's cognitive workload. Any mental strategy which can reduce or facilitate the pilot's increasing cognitive workload should be investigated. As May and Kahnweiler (2000) write, "The solution may lie in…finding creative ways to devote more participant training time to those skill sets that really matter to the strategic direction of the organization."

References

Abed, F. 1994. Visual puns as interactive illustrations: Their effects on recognition memory. Metaphor and Symbolic Activity, 9(1), 45-60.

Anderson, J.R. 1983. The Architecture of Cognition. Cambridge, Massachusetts: Harvard University Press.

Anderson, J.R. and Reder, L.M. 1999a. The fan effect: New results and new theories. Journal of Experimental Psychology: General, 128(2), 186-197.

Anderson, J.R. and Reder, L.M. 1999b. Process, not representation: Reply to Radvansky (1999). Journal of Experimental Psychology: General, 128(2), 207-210.

Ashman, A.F. and Conway R.N.F. 1997. An Introduction to Cognitive Education. Theory and applications. New York, NY: Routledge.

Bellezza, F.S. 1992. The mind's eye in expert memorizers' descriptions of remembering. Metaphor and Symbolic Activity, 7(3 and 4), 119-133.

Blessing, S.B. and Anderson, J.R. 1996. How people learn to skip steps. Journal of Experimental Psychology: Learning, Memory and Cognition, 22(3), 576-598.

Brew, C.R. 2002. Kolb's learning style instrument: Sensitive to gender. Educational and Psychological Measurement, 62(2), 373-390.

Carney, R.N. and Levin, J.R. 2002. Pictorial illustrations *still* improve students' learning from text. Educational Psychology Review, 14(1), 5-26.

Carney, R.N. and Levin, J.R. 2003. Promoting higher-order learning benefits by building lower-order mnemonic connections. Applied Cognitive Psychology, 17, 563-575.

Carr, T.H. 1986. Perceiving visual language. In K.R. Boff, L. Kaufman, and J.P. Thomas (Eds.), Handbook of Perception and Human Performance: Vol II. Cognitive Processes and Performance (pp. 29-12 – 29-13). New York: John Wiley and Sons.

Cassidy, S. and Eachus, P. 2000. Learning styles: An overview of theories, models, and measures. Educational Psychology, 24, 419-444.

Cherry, K.E., Dokey, D.K., Reese, C.M. and Brigman S. 2003. Pictorial illustrations enhance memory for sentences in younger and older adults. Experimental Aging Research, 29, 353-370.

Cherry, K.E., Park, D.C., Frieske, D.A. and Smith, A.D. 1996. Verbal and pictorial elaborations enhance memory in younger and older adults. Aging, Neuropsychology, and Cognition, 3, 15-29.

Clarion University of Pennsylvania. n.d. Research Design Explained: Chapter 5 Glossary. Retrieved August 16, 2006, from http://psy1.clarion.edu/mm/StudyRDE/C11WebStuff/c11_Vocabulary/C11WebKeyTerms.html.

Cox, B.D. 2001. Children's Use of Mnemonic Strategies: Variability in response to metamemory training. The Journal of Genetic Psychology, 155(4), 423-442.

Craik, F.I.M. and Lockhart, R.S. 1972. Levels of processing: A framework for memory research. Journal of Verbal Learning and Verbal Behavior, 11, 671-184.

Cumbie, M. 2003. Emergency procedures – know them before you need them. Flightfax, 31(10), 6-8.

Dretske, F. 1995. Attention and visual perception: Analyzing divided attention. In D.N. Osherson (General Ed.) and S.M. Kosslyn and D.N. Osherson (Vol. Eds.), An invitation to cognitive science: Vol. 2. Visual Cognition (2nd ed.). Cambridge, MA: MIT Press.

DSS Research. n.d. Researcher's Toolkit. Statistical Power Calculator. Retrieved June 18, 2005, from http://www.dssresearch.com/toolkit/spcalc/power_a2.asp.

Dunn, R. 1983. Learning style and its relationship to exceptionality at both ends of the continuum. Exceptional Children, 49, 496-506.

Dunn, R.S. and Dunn, K.J. 1979. Learning styles/teaching styles: Should they match? Educational Leadership, 36, 238-244.

Estrada, A. and Dumond, S. 2006. A survey of aviator perceptions of aviation emergency procedure training and recall (Report No. 2006-06). Fort Rucker, AL: United States Army Aeromedical Research Laboratory.

Farkas, R.D. 2003. Effects of traditional versus learning-styles instructional methods on middle school students. The Journal of Educational Research, 97(1), 42-51.

Felder, R. 1993. Reaching the second tier: Learning and teaching styles in college science education. Journal of College Science Teaching, 23(5), 286-290.

Freedman, R.D. and Stumpf, S.A. 1978. What can one learn from the learning style inventory? Academy of Management Journal, 21(2), 275-282.

Goll, P.S. 2004. Mnemonic strategies: Creating schemata for learning enhancement. Education, 125(2), 306-312.

Haber, R.N. 1969. Introduction. In R.N. Haber (Ed.), Information-processing approaches to *visual perception*. New York: Holt, Rinehart, and Winston.

Haber, R.N. 1970. How we remember what we see. Scientific American, 222(5), 104-112.

Harrison, G., Andrews, J., and Saklofske, D. (2003). Current perspectives on cognitive learning styles. *Education Canada, 43*(2), 44-47.

Headquarters, Department of the Army. 1996. Aircrew Training Program Commander's Guide to Individual and Crew Standardization. (Training Circular 1-210, with Change 1). Washington, DC: U.S. Government Printing Office.

Headquarters, Department of the Army. 2003. Operator's Manual for UH-60A Helicopter, UH-60L Helicopter, EH-60A Helicopter. (Technical Manual 1-1520-237-10, with Change 1). Washington, DC: U.S. Government Printing Office.

Herrmann, D., Raybeck, D. and Gruneberg, M. 2002. Improving memory and study skills. Advances in theory and practice. Seattle, WA: Hogrefe and Huber Publishers.

Hollingworth, A. and Henderson, J.M. 2002. Accurate visual memory for previously attended objects in natural scenes. Journal of Experimental Psychology: Human Perception and Performance, 28(1), 113-136.

Hollingworth, A., Williams, C.C. and Henderson, J.M. 2001. To see and remember: Visually specific information is retained in memory from previously attended objects in natural scenes. Psychonomic Bulletin & Review, 8(4), 761-768.

Hope, J.W. and Pate, L.E. 1988. A cognitive expectancy analysis of compliance decisions. Human Relations, 41, 739-751.

Hwang, Y. and Levin, J.R. 2002. Examination of middle-school student's independent use of a complex mnemonic system. The Journal of Experimental Education, 71(1), 25-38.

Jensen, R.S. (Ed.). 1998. Aviation Psychology. Brookfield, VT: Gower Publishing Company.

Kane, P.R. and Darling, L.A.H. 2002. Learning the pedagogy of change. Independent School, 62(1).

Keefe, J.W. 1979. An overview. In J.W. Keefe (Ed.), Student learning styles: Diagnosing and prescribing programs. Reston, VA: National Association of Secondary School Principals.

Keysers, C., Xiao, D.-K., Földiák, P., and Perrett, D.I. 2005. Out of sight but not out of mind: The neurophysiology of iconic memory in the superior temporal sulcus. Cognitive Neurophysiology, 22(3/4), 316-332.

King-Friedrichs, J. 2001. Brain-friendly techniques for improving memory. Educational Leadership, 59(3), 76-79.

Kleinheksel, K.A. and Summy, S.E. 2003. Enhancing student learning and social behavior through mnemonic strategies. TEACHING Exceptional Children, 36(2), 30-35.

Kolb, D.A. 1976. Management and the learning process. California Management Review, 18(3), 21- 31.

Kolb, D.A. 1981. Experiential learning theory and the learning style inventory: A reply to Freedman and Stumpf. *Academy of Management. The Academy of Management Review*, 6(2), 289-296.

Kosslyn, S.M. 2005. Mental images and the brain. Cognitive Neurophysiology, 22(3/4), 333-347.

Krätzig, G.P. and Arbuthnott, K.D. 2006. Perceptual learning style and learning proficiency: A test of the hypothesis. Journal of Educational Psychology, 98(1), 238-246.

Kuhn, D. 2000. Does memory development belong on an endangered topic list? Child Development, 71(1), 21-25.

Levin, M.E. and Levin, J.R. 1990. Scientific mnemonomies: Methods for maximizing more than memory. American Educational Research Journal, 27, 301-321.

Leedy, P.D. and Ormrod, J.E. 2001. Practical Research. Planning and Design (7th ed.). Upper Saddle River, NJ: Merrill Prentice-Hall.

Lines, R. 2004. Influence of participation in strategic change: resistance, organizational commitment and change goal achievement. Journal of Change Management, 4(3), 193-215.

Lohri-Posey, B. 2003. Determining learning style preferences of students. Nurse Educator, 28(2), 54.

Loo, R. 2002. A meta-analytic examination of Kolb's learning style preferences among business majors. Journal of Education for Business, 77(5), 252-256.

Loo, R. 2004. Kolb's learning styles and learning preferences: Is there a linkage? Educational Psychology, 24(1), 99-108.

Mastropieri, M.A. and Scruggs, T.E. 1998. Enhancing school success with mnemonic strategies. Intervention in School & Clinic, 33(4).

May, G.L. and Kahnweiler, W.M. 2000. The effect of a mastery practice design on learning and transfer in behavior modeling training. Personnel Psychology, 53(2), 353-373.

Miller, R. H. n.d. Web interface design: learning from our past. Retrieved September 20, 2005, from http://athos.rutgers.edu/~shklar/www4/rmiller/rhmpapr.html.

Mindtools. n.d. Tools for improving your memory. Retrieved May 21, 2005, from http://www.mindtools.com/pages/main/newMN_TIM.htm.

Moley, B.E. and Hart, S.S. 1992. The teacher's role in facilitating memory and study strategy development in the elementary classroom. Child Development, 63(3), 653-672.

Morgan, S.J. 2005. More than pictures? An exploration of visually dominant magazine ads as arguments. Journal of Visual Literacy, 25(2), 145-166.

Morrel, R.W. and Park, D.C. 1993. The effects of age, illustrations, and task variables on the performance of procedural assembly tasks. Psychology and Aging, 8(3), 389-399.

Munro, R.A. and Rice-Munro, E.J. 2004. Learning styles, teaching approaches, and technology. The Journal for Quality and Participation, 27(1), 26-32.

Nickerson, R.S. 1965. Short-term memory for complex meaningful visual configurations: A demonstration of capacity. Canadian Journal of Psychology, 19(2), 155-160.

Noice, H. 1992. Elaborate memory strategies of professional actors. Applied Cognitive Psychology, 6, 417-427.

Pirolli, P. and Card, S. 1999. Information foraging. Psychological Review, 106(4), 643-675.

Potter, M.C. 1976. Short-term conceptual memory for pictures. Journal of Experimental Psychology: Human Learning and Memory, 2(5), 509-522.

Potter, M.C. and Faulconer, B. 1975. Time to understand pictures and words. Nature, 253, 437-438.

Potter, M.C., Kroll, J., and Harris, C. 1979. Comprehension and memory in rapid sequential reading. In R.S. Nickerson (Ed.), Attention and performance, VIII. Hillsdale, N.J.: Erlbaum.

Reed, S.K. 2004. Cognition. Theory and Applications (6th ed.). Belmont, CA: Wadsworth/ Thomson Learning.

Sadler-Smith, E. 1997. Learning style: Frameworks and Instruments. Educational Psychology, 17, 51-63.

Schneider, W. and Bjorklund, D. 1998. Memory. In W. Damon (Series Ed.) and D. Kuhn and R. Siegler (Vol. Eds.), Handbook of child psychology: Vol. 2.Cognition, language, and perception (5th ed., pp.467-522). New York: Wiley.

Shepard, R.N. 1967. Recognition memory for words, sentences, and pictures. Journal of Verbal Learning and Verbal Behavior, 6, 156-163.

Simons, D.J. 1996. In sight, out of mind: When object representations fail. Psychological Science, 7(5), 301-305.

Standing, L., Conezio, J. and Haber, R.N. 1970. Perception and memory for pictures: Single-trial learning of 2500 visual stimuli. Psychonomic Science, 19(2), 73-74.

Szewczyk, J. 2003. Difficulties with the novices' comprehension of the computer-aided design (CAD) interface: understanding visual representations of CAD tools. Journal of Engineering Design, 14(2), 169-185.

U.S. Army Aviation Center. 2000. Instructor Pilot Handbook, Instructing Fundamentals (PFN 0680-4). Fort Rucker, Alabama.

VARK 16 June 2005. A Guide to Learning Styles. Available at http://www.vark-learn.com/english/page.asp?p=copyright.

Walley, C. 1995. Looking at school change. Childhood Education, 71(5), 258-260.

Watkins, J.K., Miller, E., and Brubaker, D. 2004. The role of the visual image: What are students really learning from pictorial representations? Journal of Visual Literacy, 24(1), 23-40.

Webster's Ninth New Collegiate Dictionary. 1985. Springfield, MA: Merriam-Webster.

Wikipedia. n.d. Likert scale. Retrieved June 20, 2005, from http://en.wikipedia.org/wiki/Likert_scale.

Wolfe, K., Bates, D., Manikowske, L., and Amundsen, R. 2005. Learning Styles: Do they differ by discipline. Journal of Family and Consumer Sciences, 97(4), 18-22.

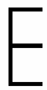
Zapalska, A.M., and Dabb, H. 2002. Learning Styles. Journal of Teaching in International Business, 13, 77-97.

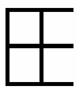
Appendix A.

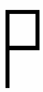
Intuitive Pictorial System symbols and rules.

Basic Aircraft Systems Symbols

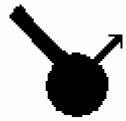
Engine Systems

 = Single Engine

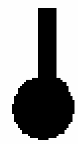
 = Dual Engine

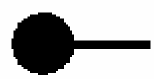
 = APU (Auxiliary Power Unit)

Power Control Lever Positions

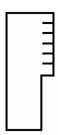
 = ECU Lockout

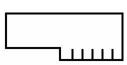
 = Fly

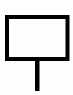
 = Idle

 = Off

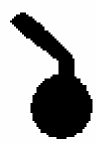
Flight Controls

 = Cyclic

 = Collective

 = Pedals

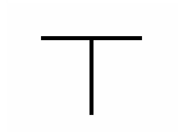
Fuel Selector Positions

 = Crossfeed

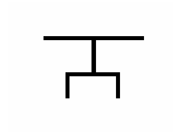
 = Direct

 = Off

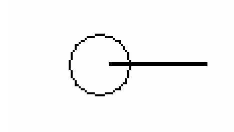
Main Rotor



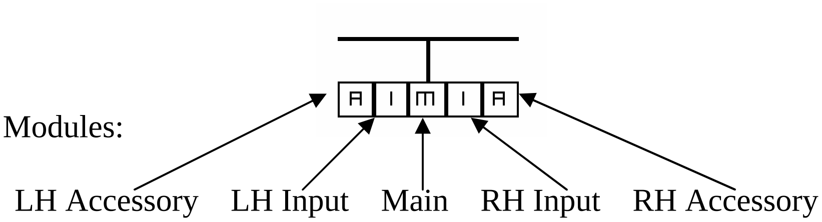
External Cargo/Stores



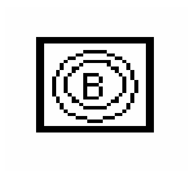
Tail Rotor



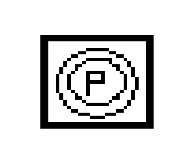
Transmission Modules:



Fuel Boost Pump

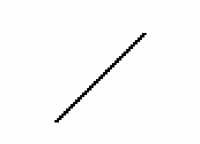


Fuel Pump – APU Boost



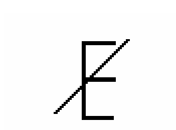
Basic Action Symbols

System Shutdown:

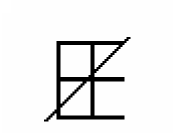


= Intentional System Shutdown (placed over the appropriate symbol)

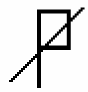
Hence:



= Emergency (Single) Engine Shutdown



= Emergency Dual Engine Shutdown



= APU Shutdown

General Actions:

= “Forward” or “Increasing”

= “Retard” or “Aft” or “Decreasing”

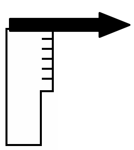
= “Adjust”

= “Up” or “Increase”

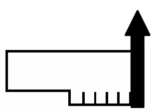
= “Down” or “Reduce” or “Decrease” or “Jettison”

= “Adjust”

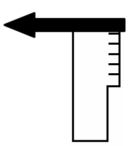
Hence:



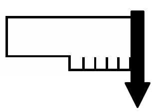
= Forward Cyclic



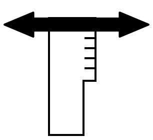
= Collective Increase



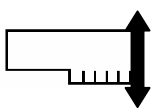
= Aft Cyclic



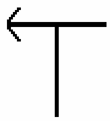
= Collective Reduce



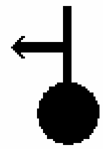
= Cyclic Adjust



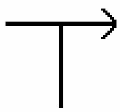
= Collective Adjust



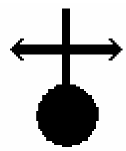
= Decreasing Rotor



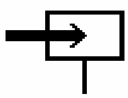
= Engine Power Control Lever – Retard



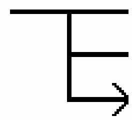
= Increasing Rotor



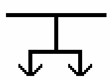
= Engine Power Control Lever – Adjust



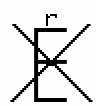
= Apply Pedal Force



= Establish Single Engine Airspeed

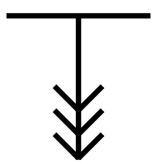


= External Cargo/ Stores – Jettison

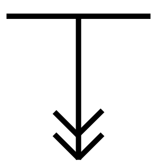


= Refer To Single Engine Failure Emergency Procedures

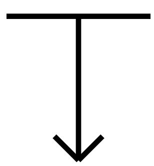
Landings:



= Autorotate



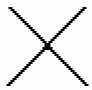
= Land as Soon as Possible



= Land as Soon as Practicable

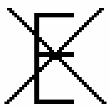
Situational Symbols

Failures:

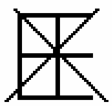


= System Failure when placed over the appropriate symbol.
= Chip when placed within the symbol.

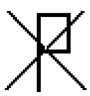
Hence:



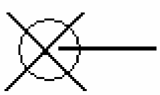
= Single Engine Failure



= Dual Engine Failure



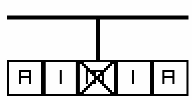
= APU Failure



= Tail Rotor Failure or Loss of Tail Rotor Thrust

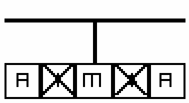
Chips:

Chip in the Main Transmission

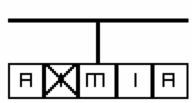


Engine Chip

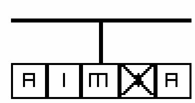
Chips in the LH and RH Input Modules



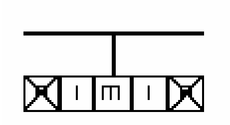
Chip in the LH Input Module



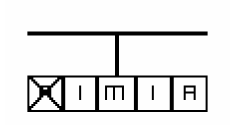
Chip in the RH Input Module



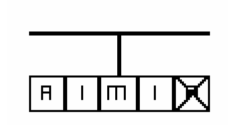
Chips in the LH and RH Accessory Modules



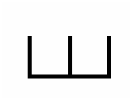
Chip in the LH Accessory Module



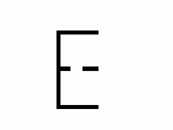
Chip in the RH Accessory Module



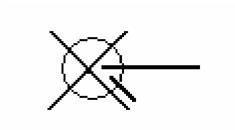
Other Situational Symbols:



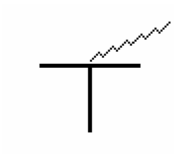
= Engine Compressor Stall (engine symbol on its side)



= Engine High Speed Shaft Failure



= Tail Rotor Quadrant Failure (loss of control)



= Lightning Strike

General Rules

1. Always use right seat perspective.
2. An arrow pointing to the right depicts “increase,” an arrow pointing to the left depicts “decrease,” and an arrow pointing left AND right indicates “adjust” (either increase or decrease, or both).
3. The large symbol is the situation, the smaller symbols are the procedural steps.
4. “E” refers to engine, “T” refers to main rotor, and “/” refers to shutdown.
5. “X” over the symbol depicts failure, while “x” within the symbol depicts a chip.
6. When using the IPS to remember emergency procedures, try to imprint the whole image of a procedure (the situation symbol and step symbols together) in your memory as one picture.

Appendix B.

Emergency Procedures Knowledge Test.

Participant #______________.

1. What is the first step in the event of an engine compressor stall?

2. What is the last step in the event of a loss of tail rotor thrust when not operating at low airspeed or at a hover?

3. What is the emergency procedure for a tail rotor quadrant caution light with an accompanying loss of tail rotor control?

4. What are the steps of an emergency engine shutdown?

5. During a single-engine failure, if continued flight is possible, what two steps should be performed after adjusting the collective and jettisoning the external stores?

6. If % RPM R is increasing and the engine does not respond to engine power control lever movement between Fly and Idle, what steps should be taken after establishing single engine airspeed?

7. What should be done in the event of a dual-engine failure?

8. In the event of a high-speed shaft failure, what is Step 2 and what is Step 4?

9. What is the first thing to do when tail rotor thrust is lost while at a hover?

10. When should you land when % RPM R is decreasing?

11. In the event of a chip in the right hand (RH) input module, what step(s) must be performed?

12. An engine chip caution light appears for the #1 engine. What are the three numbered steps in the procedure?

13. You must be prepared to perform what steps following a lightning strike?

14. A chip light appears indicating a chip in the main transmission. What must you do?

15. When should the engine power control levers be moved to the OFF position during a loss of tail rotor thrust while at a hover?

Appendix C.

Emergency Procedures Knowledge Test answer sheet.

Participant #_______________.

1. What is the first step in the event of an engine compressor stall?

Collective - Reduce

2. What is the last step in the event of a loss of tail rotor thrust when not operating at low airspeed or at a hover?

ENG POWER CONT levers – OFF (when intended point of landing is assured).

3. What is the emergency procedure for a tail rotor quadrant caution light with an accompanying loss of tail rotor control?

1. Collective – Adjust.
2. LAND AS SOON AS PRACTICABLE.

4. What are the steps of an emergency engine shutdown?

1. ENG POWER CONT lever(s) – OFF.
2. ENG FUEL SYS selector(s) – OFF.
3. FUEL BOOST PUMP CONTROL switch(es) – OFF.

5. During a single-engine failure, if continued flight is possible, what two steps should be performed after adjusting the collective and jettisoning the external stores?

4. Establish single-engine airspeed.
5. LAND AS SOON AS PRACTICABLE.

6. If % RPM R is increasing and the engine does not respond to engine power control lever movement between Fly and Idle, what steps should be taken after establishing single engine airspeed?

4. Perform EMERG ENG SHUTDOWN (affected engine).
5. Refer to single engine failure emergency procedures.

7. What should be done in the event of a dual-engine failure?

AUTOROTATE

8. In the event of a high-speed shaft failure, what is Step 2 and what is Step 4?

2. Establish single engine airspeed.
4. Refer to single engine failure emergency procedures.

9. What is the first thing to do when tail rotor thrust is lost while at a hover?

Collective - Reduce

10. When should you land when % RPM R is decreasing?

Land as soon as practicable.

11. In the event of a chip in the right hand (RH) input module, what step(s) must be performed?

1. ENG POWER CONT lever on affected engine – IDLE.
2. LAND AS SOON AS POSSIBLE.

12. An engine chip caution light appears for the #1 engine. What are the three numbered steps in the procedure?

1. ENG POWER CONTROL lever – Retard to reduce torque on affected engine.
2. EMER ENG SHUTDOWN (affected engine).
3. Refer to single engine failure emergency procedures.

13. You must be prepared to perform what steps following a lightning strike?

1. ENG POWER CONT levers – Adjust as required to control % RPM.
2. LAND AS SOON AS POSSIBLE.

14. A chip light appears indicating a chip in the main transmission. What must you do?

LAND AS SOON AS POSSIBLE

15. When should the engine power control levers be moved to the OFF position during a loss of tail rotor thrust while at a hover?

(5 to 10 feet above touchdown)

Appendix D.

Subjective Assessment Survey.

Participant #___________________

Please circle the responses that most accurately answer the following questions.

CIRCLE ONLY ONE ANSWER PER QUESTION.

1. I found that the Intuitive Pictorial System (IPS) was not a useful tool (strategy) for memorizing the aircraft's emergency procedures.

   Strongly agree   Agree   Neutral   Disagree   Strongly disagree

2. I prefer my own system of memorization over that of the IPS.

   Strongly agree   Agree   Neutral   Disagree   Strongly disagree

3. If given the choice, I would not use the IPS in the future.

   Strongly agree   Agree   Neutral   Disagree   Strongly disagree

4. I believe the IPS just adds to the amount of material I already have to learn and is, thus, an additional burden.

   Strongly agree   Agree   Neutral   Disagree   Strongly disagree

5. Generally speaking, the symbols used in the IPS were not intuitive to me (easily recognized without evident thinking).

   Strongly agree   Agree   Neutral   Disagree   Strongly disagree

6. I believe the IPS is too complex a system to benefit the average new aviation student.

   Strongly agree   Agree   Neutral   Disagree   Strongly disagree

7. I believe the IPS has not improved my ability to recall emergency procedures when needed.

   Strongly agree   Agree   Neutral   Disagree   Strongly disagree

8. I don’t believe that the IPS should be taught to future aviation students.

   Strongly agree Agree Neutral Disagree Strongly disagree

9. The IPS did not assist me in memorizing the required emergency procedures.

   Strongly agree Agree Neutral Disagree Strongly disagree

10. I consider learning the IPS to be a waste of valuable time that I could have used memorizing the emergency procedures my own way.

    Strongly agree Agree Neutral Disagree Strongly disagree

11. I would not recommend integrating and employing the IPS as part of the U. S. Army’s official flight training syllabus.

    Strongly agree Agree Neutral Disagree Strongly disagree

12. I believe the IPS may cause confusion to the majority of pilots.

    Strongly agree Agree Neutral Disagree Strongly disagree

13. The IPS symbols should not be used in an aircraft emergency checklist for use in the cockpit instead of written text.

    Strongly agree Agree Neutral Disagree Strongly disagree

14. I believe the IPS could actually cause or contribute to confusion during an actual aircraft emergency situation.

    Strongly agree Agree Neutral Disagree Strongly disagree

15. Below please provide any additional comments regarding the IPS and its symbols; i.e., specific symbols that were or were not particularly intuitive, specific symbols which need refinement or change, recommendations for future applications.

Appendix E.

Subjective Assessment Survey scoring procedures.

- Answers to the Subjective Assessment Surveys will be scored as such:

Strongly agree	= 5 points
Agree	= 4 points
Neutral	= 3 points
Disagree	= 2 points
Strongly disagree	= 1 point

- Total scores will be converted to the following classifications (groups):

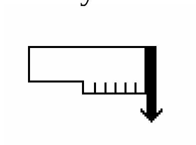
14 – 28 = positive assessment
29 – 41 = positive to neutral assessment
42 = neutral assessment
43 – 55 = neutral to negative assessment
56 – 70 = negative assessment

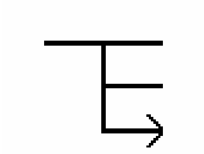
Appendix F.

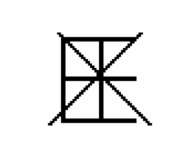
Symbol Recognition Test.

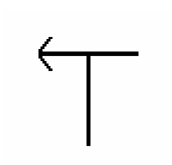
Participant #_______________.

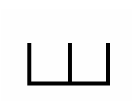
Identify each of the following symbols by writing in the aircraft system, situation, or action symbolized by it.

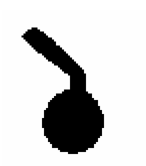
1.  =

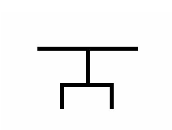
2.  =

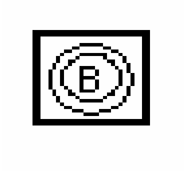
3.  =

4.  =

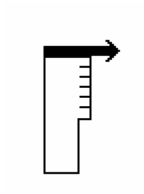
5.  =

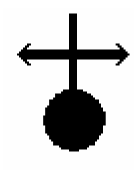
6.  =

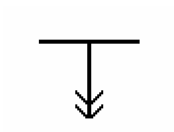
7.  =

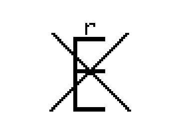
8. 

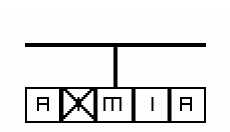
=

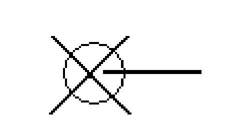
9.  =

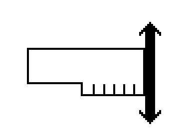
10.  =

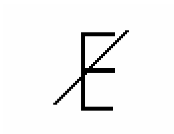
11.  =

12.  =

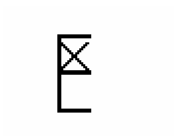
13.  =

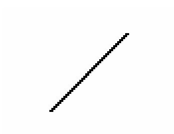
14.  =

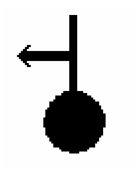
15.  =

16.  =

17.  =

18.  =

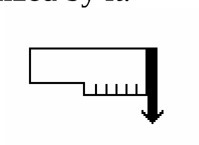
19.  =

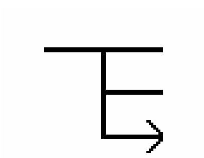
20.  =

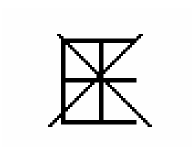
Appendix G.

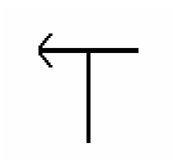
Symbol Recognition Test answer sheet.

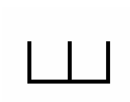
Participant #_______________.
Identify each of the following symbols by writing in the aircraft system, situation, or action symbolized by it.

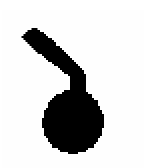
1.  = Collective Reduce

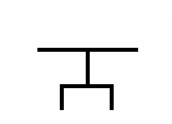
2.  = Establish Single Engine Airspeed

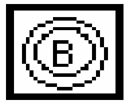
3.  = Dual Engine Failure

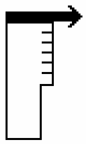
4.  = Decreasing Rotor

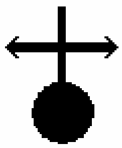
5.  = Engine Compressor Stall

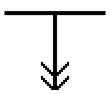
6.  = Crossfeed

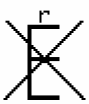
7.  = External Cargo/Stores

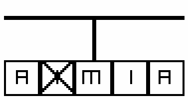
8.  = Fuel Boost Pump

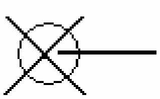
9.  = Forward Cyclic

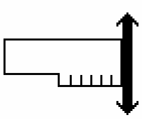
10.  = Engine Power Control Lever – Adjust

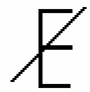
11.  = Land as Soon as Possible

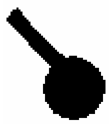
12.  = Refer To Single Engine Failure Emergency Procedures

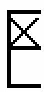
13.  = Chip in the LH Input Module

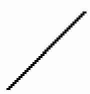
14.  = Tail Rotor Failure or Loss of Tail Rotor Thrust

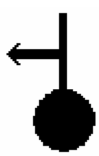
15.  = Collective Adjust

16.  = Emergency (Single) Engine Shutdown

17.  = Engine Power Control Lever FLY

18.  = Engine Chip

19.  = Intentional System Shutdown (placed over the appropriate symbol)

20.  = Engine Power Control Lever – Retard

Appendix H.

The VARK Questionnaire.

Participant #______________________.   Revised version - January 2005.

This questionnaire aims to find out something about your preferences for the way you work with information. You will have a preferred learning style and one part of that learning style is your preference for the intake and output of ideas and information.

Choose the answer which best explains your preference and click on the box next to the letter. Please select more than one response if a single answer does not match your perception.

Leave blank any question which does not apply.

1. You are about to give directions to a person who is standing with you. She is staying in a hotel in town and wants to visit your house later. She has a rental car. I would:

    a. draw or provide a map on paper.
    b. tell her the directions.
    c. write down the directions (without a map).
    d. collect her from the hotel in a car.

2. You are not sure whether a word should be spelled 'dependent' or 'dependant'. I would:

    a. look it up in the dictionary.
    b. see the word in my mind and choose by the way it looks.
    c. sound it out in my mind.
    d. write both versions down on paper and choose one.

3. You have just received a copy of your itinerary for a world trip. This is of interest to some friends. I would:

    a. phone, text or email them and tell them about it.
    b. send them a copy of the printed itinerary.
    c. show them on a map of the world.
    d. describe what I plan to do at each place on the itinerary.

4. You are going to cook something as a special treat for your family. I would:

    a. cook something familiar without the need for instructions.
    b. thumb through the cookbook looking for ideas from the pictures.
    c. refer to a specific cookbook where there is a good recipe.

5. A group of tourists has been assigned to you to find out about wildlife reserves or parks. I would:

    a. drive them to a wildlife reserve or park.
    b. show them slides and photographs.
    c. give them pamphlets or a book on wildlife reserves or parks.
    d. give them a talk on wildlife reserves or parks.

6. You are about to purchase a new CD player. Other than price, what would most influence your decision?

    a. The salesperson telling you what you want to know.
    b. Reading the details about it.
    c. Playing with the controls and listening to it.
    d. It looks really smart and fashionable.

7. Recall a time in your life when you learned how to do something like playing a new board game. Try to avoid choosing a very physical skill, e.g. riding a bike. I learned best by:

    a. visual clues -- pictures, diagrams and charts.
    b. written instructions.
    c. listening to somebody explaining it.
    d. doing it or trying it.

8. You have a knee problem. I would prefer that the doctor:

    a. told me what was wrong.
    b. showed me a diagram of what was wrong.
    c. used a model of a knee to show me what was wrong.

9. You are about to learn to use a new program on a computer. I would:

    a. sit down at the keyboard and experiment with the program.
    b. read the manual that came with the program.
    c. telephone or text a friend and ask questions about the program.

10. You are staying in a hotel and have a rental car. You would like to visit friends whose address/location you do not know. I would like them to:

    a. draw me a map on paper or provide a map from the internet.
    b. tell me the directions.
    c. write down the directions (without a map).
    d. collect me from the hotel in a car.

11. Apart from the price, what would most influence your decision to buy a particular textbook?

    a. I have used a copy before.
    b. A friend talking about it.
    c. Quickly reading parts of it.
    d. The way it looks is appealing.

12. A new movie has arrived in town. What would most influence your decision to go (or not go)?

    a. I heard a review about it on the radio.
    b. I read a review about it.
    c. I saw a preview of it.

13. Do you prefer a teacher who likes to use:

    a. a textbook, handouts and readings.
    b. flow diagrams, charts and graphs.
    c. field trips, models, laboratories and practical sessions.
    d. class or email discussion, online chat groups and guest speakers.

Appendix I.

VARK scoring chart.

Use the following scoring chart to find the VARK category that each of the answers corresponds to. Circle the letters that correspond to the answers, e.g., if question #3 was answered b and c, circle R and V in the question 3 row.

Question	a category	b category	c category	d category
3	A	R	V	K

Scoring chart:

Question	a category	b category	c category	d category
1	V	A	R	K
2	R	V	A	K
3	A	R	V	K
4	K	V	R	
5	K	V	R	A
6	A	R	K	V
7	V	R	A	K
8	A	V	K	
9	K	R	A	
10	V	A	R	K
11	K	A	R	V
12	A	R	V	
13	R	V	K	A

Calculating the scores:

Count the number of each of the VARK letters that have been circled to get the score for each VARK category.

Total number of Vs circled =

Total number of As circled =

Total number of Rs circled =

Total number of Ks circled =

Calculating the preferences / Scoring instructions:

Because respondents can choose more than one answer for each question the scoring is complex. It can be likened to a set of four stepping-stones across water.

1. Add up the scores, V + A + R + K = _______.

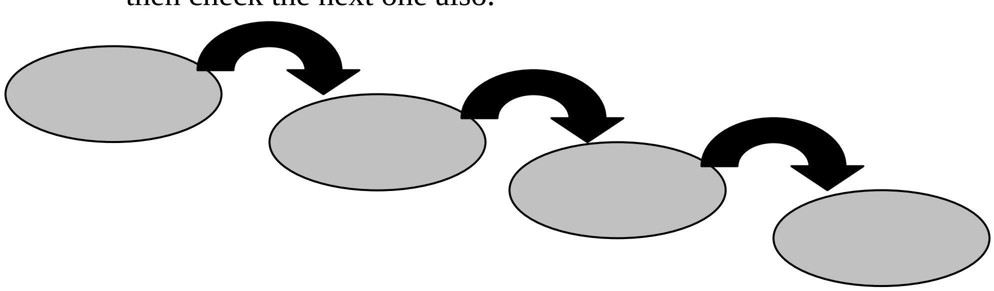
2. Enter the scores from highest to lowest on the stones below, with their V, A, R, and K labels.

3. The stepping distance comes from the following table:

The total of the four VARK scores is	The stepping distance is
10 – 16	1
17 – 22	2
23 – 26	3
More than 26	4

4. The first preference is the highest score, so check the first stone as one of the preferences and enter its label on the stone.

5. If the next stone can be reached with a step equal to or less than the stepping distance, then check the next one also.



Scoring VARK Stepping-Stones:

Once the next stone cannot be reached, the respondent's set of preferences have been defined. If there is more than one preference checked, the respondent has multimodal preferences. If only the first stone is checked, then the respondent has a single preference.

For those with a Single Preference:

If a respondent has a single preference (V, A, R, or K), the preference is mild, strong, or very strong. Use the table below (Result Table) to find this out.

1. Use the total number of responses (from step 1 above). This is used for finding the place in Column One. Read across from the appropriate line in Column One.

2. Now take the difference between the highest score and the next highest score. Read across the line until reaching the column that shows the difference between the highest score and the next highest score.

Column One	The difference between the two highest scores was:						
Total number of responses is:	**Zero.** They were equal.	**1**	**2**	**3**	**4**	**5**	**6 or more**
less than 17	**Multi-modal**	**Multi-modal**	**Mild**	**Strong**	**Very Strong**	**Very Strong**	**Very Strong**
between 17 and 22	**Multi-modal**	**Multi-modal**	**Multi-modal**	**Mild**	**Strong**	**Very Strong**	**Very Strong**
between 23 and 26	**Multi-modal**	**Multi-modal**	**Multi-modal**	**Multi-modal**	**Mild**	**Strong**	**Very Strong**
more than 26	**Multi-modal**	**Multi-modal**	**Multi-modal**	**Multi-modal**	**Multi-modal**	**Mild**	**Strong**

Result Table:

The strength of a single preference is:		
Mild	**Strong**	**Very strong**

Appendix J.

Study Experience Report.

Participant #________________.

How many hours per day (average) during the past week do you estimate that you spent studying the emergency procedures presented as part of this research?
____ hours.

IPS group only: How many hours per day (average) during the past week do you estimate that you spent using the symbols to study the emergency procedures presented as part of this research? (Note that both totals can equal the same number of hours.)
____ hours.

Appendix K.

General information briefing.

Slide 1

General Information About the Research Project

Arthur Estrada
Principal Investigator
US Army Aeromedical Research Laboratory
Fort Rucker, AL
255-6928

Slide 2

The Research

- This research is being conducted to determine the merits of two training methods for memorizing aviation emergency procedures.

- In order to evaluate the two methods, some of you will be taught using Method 1, while some of you will be taught using Method 2. I will then compare the performance of each group (through written tests) to see which group gets the highest grades. We will also be asking your opinions of the methods upon completion of the training.

Slide 3

Your Task in this Research

- You will be provided instruction on 17 UH60 Black Hawk emergency procedures. Your task is to memorize each of the selected emergency procedure steps, regardless of whether the step is underlined or non-underlined.
- The steps requiring memorization are the numbered steps. Non-numbered steps need not be memorized unless there is only one step in the procedure.
- In order to participate, you must be willing to return 7 days after you first receive instructions to take a quick written examination to check your retention. (You are encouraged to study the selected emergency procedures during the week between instruction and testing.)

Slide 4

FINALLY:

- Remember, you have the right to withdraw from the study at anytime without penalty.
- Please DO NOT to discuss your assigned system of memorization with others outside your group as this will compromise the research.
- Thank you for agreeing to participate.

Appendix L.

UH-60 aircraft/cockpit orientation presentation.

Slide 1

UH-60 Aircraft/Cockpit
Orientation Presentation

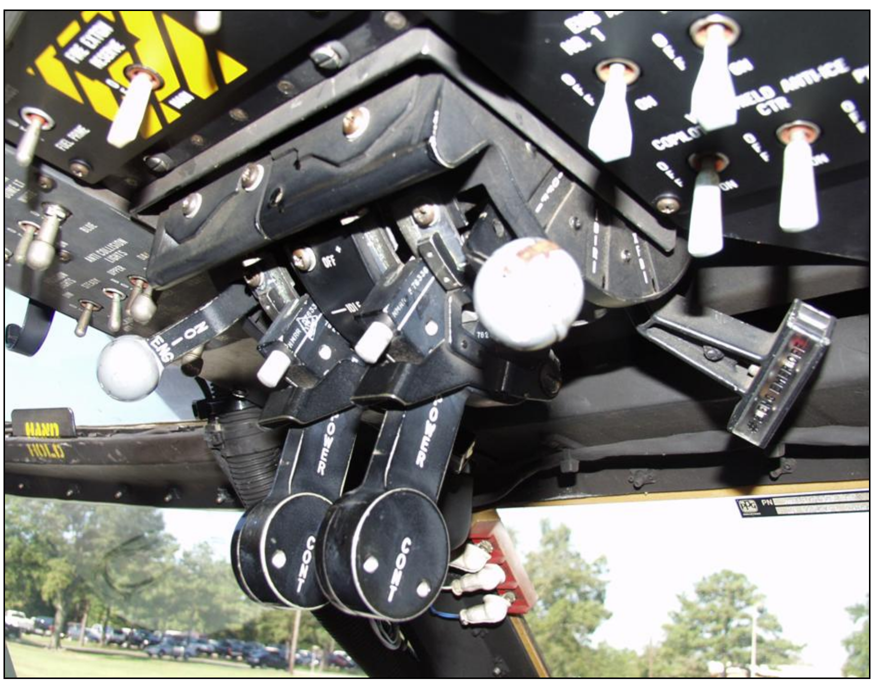
Slide 2

Slide 3

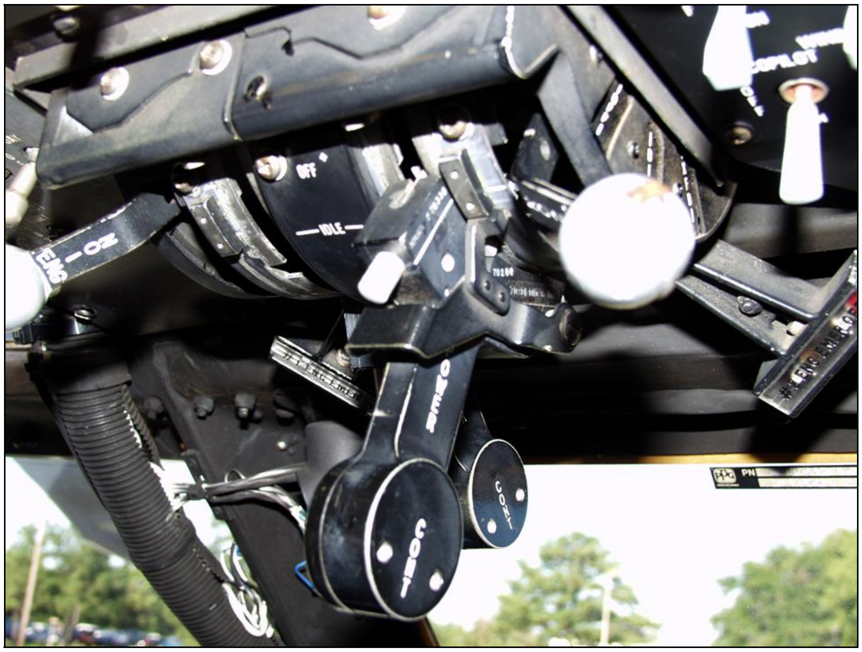
Slide 4

Slide 5

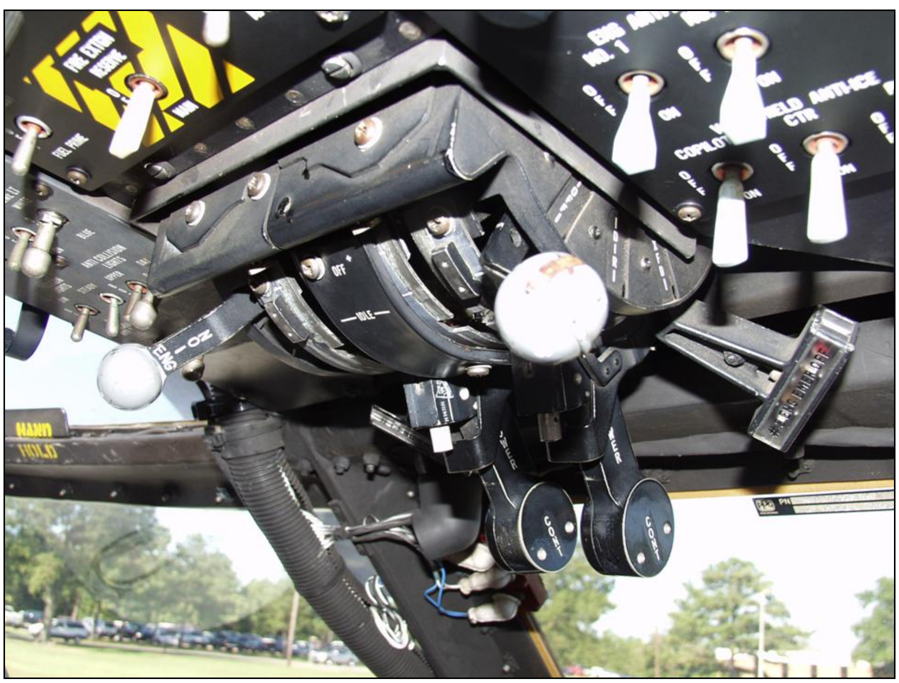
Slide 6



Slide 7



Slide 8



Slide 9

Slide 10

Slide 11

Appendix M.

Instructional PowerPoint presention (with IPS instructions).

Slide 1

UH60 Emergency Procedures Class

Slide 2

Class Outline

1. What is the Intuitive Pictorial System (IPS)?
2. What is its purpose?
3. Basic symbology and rules.
4. Selected emergency procedures: text and symbols.
5. Questions.

Slide 3

What is the Intuitive Pictorial System (IPS)?

The IPS is a novel system of intuitive pictures taught as a mnemonic strategy to facilitate learning and prompt recall of complex emergency procedures. The pictures are characterized as *intuitive* as they are formed with symbols representing aircraft parts and systems; and are easily and immediately recognizable to pilots. Thus, they should require no cognitive effort in determining their meanings.

Slide 4

What is its purpose?

Based on a survey by USAARL, many pilots report that memorizing and retaining emergency procedures can be difficult and requires a considerable amount of time rehearsing even after years of experience and practice. The consequences of forgetting them can range from an Unsatisfactory grade during flight evaluations to the more serious inability to respond to and perform correctly during an actual emergency situation.

This method of training may serve to help to improve a pilot's ability to retain the emergency procedures over time.

Slide 5

Basic Symbology and Rules

1. Always use right seat perspective.
2. An arrow pointing to the right depicts "increase", an arrow pointing to the left depicts "decrease", and an arrow pointing left AND right indicates "adjust" (either increase or decrease, or both).
3. The large symbol is the situation, the smaller symbols are the procedural steps.
4. "E" refers to engine, "T" refers to main rotor, and "/" refers to shutdown.
5. "X" over the symbol depicts failure, while "x" within the symbol depicts chip.

Slide 6

Basic Symbols

Refer to Intuitive Pictorial System Symbols and Rules study handout.*

* Available in Appendix B

Slide 7

EMERGENCY PROCEDURES

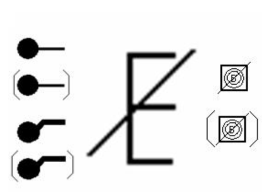
WITH

SYMBOLS

Slide 8

EMERGENCY ENG SHUTDOWN

1. **ENG POWER CONT** lever(s) – **OFF**.
2. **ENG FUEL SYS** selector(s) – **OFF**.
3. **FUEL BOOST PUMP CONTROL** switch(es) – **OFF**.



Slide 9

SINGLE-ENGINE FAILURE

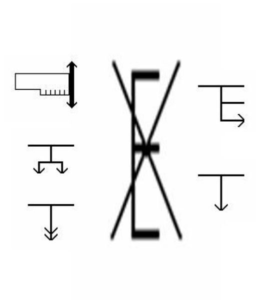
1. Collective – Adjust to maintain **% RPM R**.
2. External cargo/stores – Jettison (if required).

If continued flight is not possible:

3. LAND AS SOON AS POSSIBLE.

If continued flight is possible:

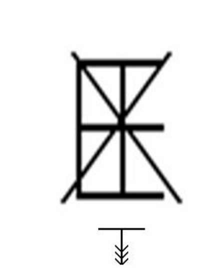
4. Establish single-engine airspeed.
5. LAND AS SOON AS PRACTICABLE.



Slide 10

DUAL-ENGINE FAILURE

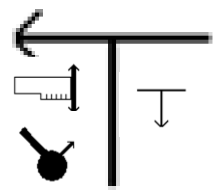
AUTOROTATE



Slide 11

DECREASING % RPM R

1. <u>Collective - Adjust</u> to control **% RPM R.**
2. **<u>ENG POWER CONT</u>** <u>lever</u> **<u>-</u>** **<u>LOCKOUT</u>** low % **TRQ/TGT TEMP** engine. Maintain **% TRQ** approximately 10% below other engine.
3. Land as soon as practicable.



Slide 12

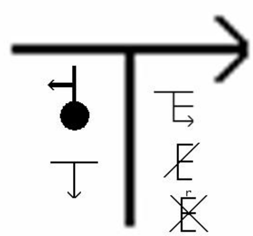
INCREASING % RPM R

1. **<u>ENG POWER CONT</u>** <u>lever</u> **<u>- Retard</u>** high **% TRQ/TGT TEMP** engine, maintain **% TRQ** approximately 10% below other engine.
2. LAND AS SOON AS PRACTICABLE.

If effected engine does not respond to **ENG POWER CONT** lever movement in the range between **FLY** and **IDLE**, the HMU may be malfunctioning internally.

If this occurs:

3. Establish single engine airspeed.
4. Perform **<u>EMERG ENG SHUTDOWN (affected engine).</u>**
5. Refer to single engine failure emergency procedure.



Slide 13

ENGINE COMPRESSOR STALL

1. Collective - Reduce.

If condition persists:

2. **ENG POWER CONT** lever (affected engine) - Retard (**TGT TEMP** should decrease).

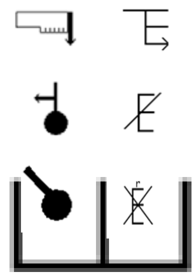
3. **ENG POWER CONT** lever (affected engine) – **FLY**.

If stall condition recurs:

4. Establish single engine airspeed.

5. EMERG ENG SHUTDOWN (affected engine).

5. Refer to single-engine failure emergency procedure.



Slide 14

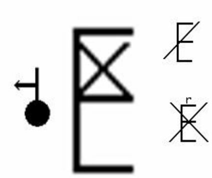
ENGINE CHIP CAUTION LIGHT APPEARS

1. **ENG POWER CONT** lever - Retard to reduce torque on affected engine.

If oil pressure is below minimum limits or if oil temperature remains above maximum limits:

2. EMER ENG SHUTDOWN (affected engine).

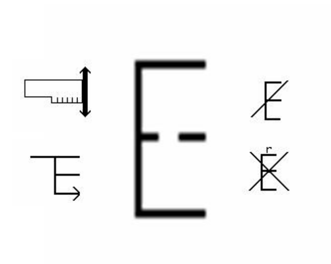
3. Refer to single-engine failure emergency procedure.



Slide 15

ENGINE HIGH-SPEED SHAFT FAILURE

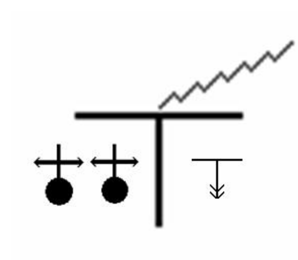
1. Collective – Adjust.
2. Establish single engine airspeed.
3. EMERG ENG SHUTDOWN (affected engine). Do not attempt to restart.
4. Refer to single-engine failure emergency procedure.



Slide 16

LIGHTNING STRIKE

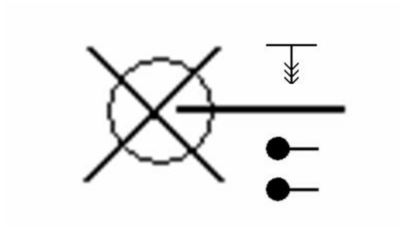
1. **ENG POWER CONT** levers – Adjust as required to control % RPM.
2. LAND AS SOON AS POSSIBLE.



Slide 17

LOSS OF TAIL ROTOR THRUST

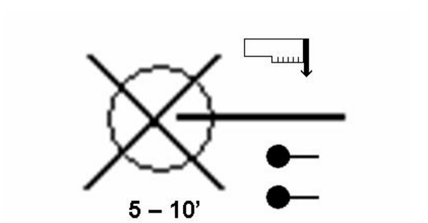
1. AUTOROTATE.
2. **ENG POWER CONT** levers – **OFF** (when intended point of landing is assured).



Slide 18

LOSS OF TAIL ROTOR THRUST at LOW AIRSPEED/HOVER

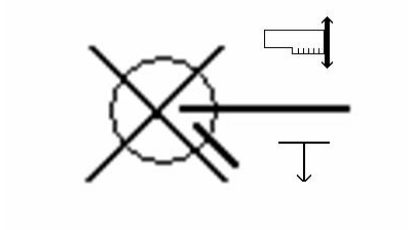
1. Collective - Reduce.
2. **ENG POWER CONT** levers – **OFF** (5 to 10 feet above touchdown).



Slide 19

TAIL ROTOR QUADRANT Caution Light with Loss of Tail Rotor Control

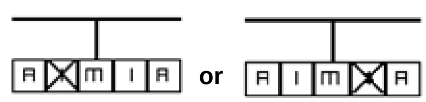
1. Collective - Adjust.
2. LAND AS SOON AS PRACTICABLE.



Slide 20

CHIP INPUT MODULE LH or RH

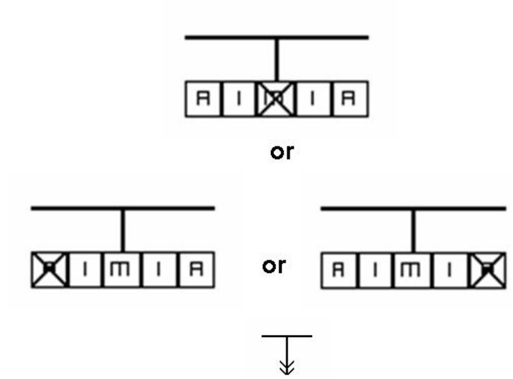
1. **ENG POWER CONT** lever on affected engine **– IDLE**.
2. LAND AS SOON AS POSSIBLE.



Slide 21

CHIP MAIN MODULE SUMP, CHIP ACCESSORY MODULE LH or RH

LAND AS SOON AS POSSIBLE.



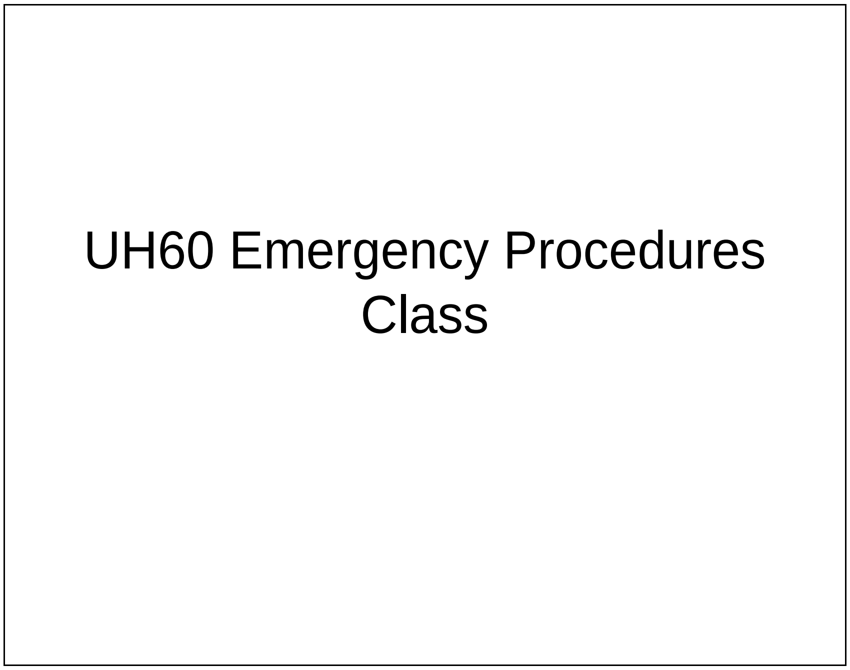
Slide 22

QUESTIONS?

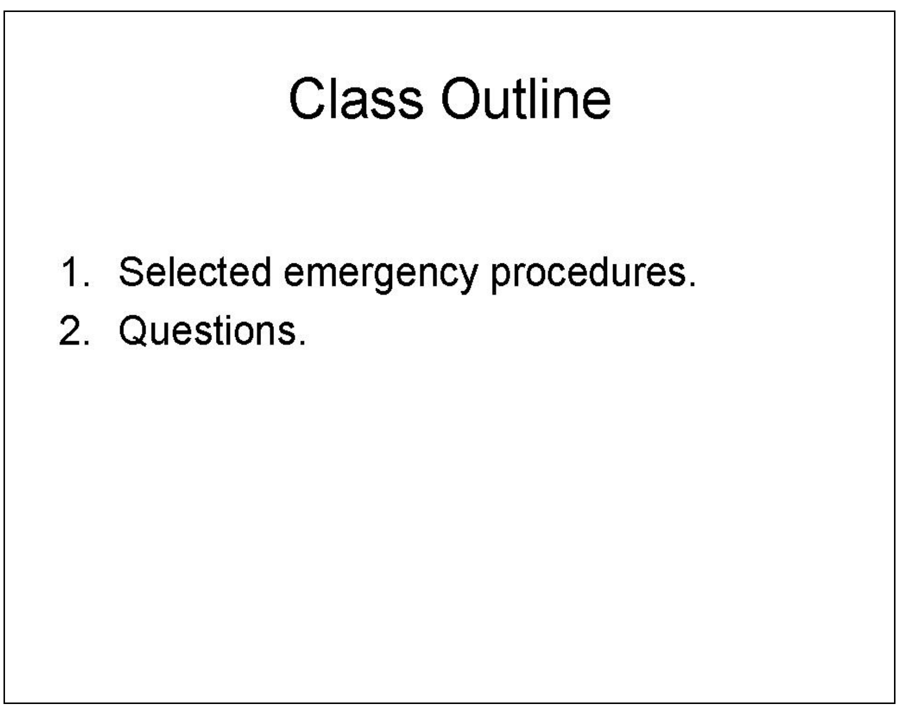
Appendix N.

Instructional PowerPoint presentation (without IPS instructions).

Slide 1



Slide 2



Slide 3

EMERGENCY ENG SHUTDOWN

1. **ENG POWER CONT** lever(s) – **OFF**.
2. **ENG FUEL SYS** selector(s) – **OFF**.
3. **FUEL BOOST PUMP CONTROL** switch(es) – **OFF**.

Slide 4

SINGLE-ENGINE FAILURE

1. Collective – Adjust to maintain **% RPM R**.
2. External cargo/stores – Jettison (if required).

If continued flight is not possible:

3. LAND AS SOON AS POSSIBLE.

If continued flight is possible:

4. Establish single-engine airspeed.
5. LAND AS SOON AS PRACTICABLE.

Slide 5

DUAL-ENGINE FAILURE

AUTOROTATE

Slide 6

DECREASING % RPM R

1. Collective - Adjust to control **% RPM R.**
2. **ENG POWER CONT** lever **- LOCKOUT** low % **TRQ/TGT TEMP** engine. Maintain **% TRQ** approximately 10% below other engine.
3. Land as soon as practicable.

Slide 7

INCREASING % RPM R

1. **ENG POWER CONT** lever **- Retard** high **% TRQ/TGT TEMP** engine, maintain **% TRQ** approximately 10% below other engine.
2. LAND AS SOON AS PRACTICABLE.

If effected engine does not respond to **ENG POWER CONT** lever movement in the range between **FLY** and **IDLE**, the HMU may be malfunctioning internally.

If this occurs:

3. Establish single engine airspeed.
4. Perform **EMERG ENG SHUTDOWN (affected engine).**
5. Refer to single engine failure emergency procedure.

Slide 8

ENGINE COMPRESSOR STALL

1. Collective - Reduce.

If condition persists:

2. **ENG POWER CONT** lever (affected engine) - Retard (**TGT TEMP** should decrease).
3. **ENG POWER CONT** lever (affected engine) – **FLY**.

If stall condition recurs:

4. Establish single engine airspeed.
5. EMERG ENG SHUTDOWN (affected engine).
5. Refer to single-engine failure emergency procedure.

Slide 9

ENGINE CHIP CAUTION LIGHT APPEARS

1. **ENG POWER CONT** lever - Retard to reduce torque on affected engine.

If oil pressure is below minimum limits or if oil temperature remains above maximum limits:

2. EMER ENG SHUTDOWN (affected engine).
3. Refer to single-engine failure emergency procedure.

Slide 10

ENGINE HIGH-SPEED SHAFT FAILURE

1. Collective – Adjust.
2. Establish single engine airspeed.
3. EMERG ENG SHUTDOWN (affected engine). Do not attempt to restart.
4. Refer to single-engine failure emergency procedure.

Slide 11

LIGHTNING STRIKE

1. **ENG POWER CONT** levers – Adjust as required to control % RPM.

2. LAND AS SOON AS POSSIBLE.

Slide 12

LOSS OF TAIL ROTOR THRUST

1. AUTOROTATE.

2. **ENG POWER CONT** levers – **OFF** (when intended point of landing is assured).

Slide 13

LOSS OF TAIL ROTOR THRUST at LOW AIRSPEED/HOVER

1. Collective - Reduce.

2. **ENG POWER CONT** levers – **OFF** (5 to 10 feet above touchdown).

Slide 14

TAIL ROTOR QUADRANT Caution Light with Loss of Tail Rotor Control

1. Collective - Adjust.

2. LAND AS SOON AS PRACTICABLE.

Slide 15

CHIP INPUT MODULE LH or RH

1. **ENG POWER CONT** lever on affected engine **– IDLE**.
2. LAND AS SOON AS POSSIBLE.

Slide 16

CHIP MAIN MODULE SUMP, CHIP ACCESSORY MODULE LH or RH

LAND AS SOON AS POSSIBLE.

Slide 17

QUESTIONS?

Appendix O.

Supplemental results.

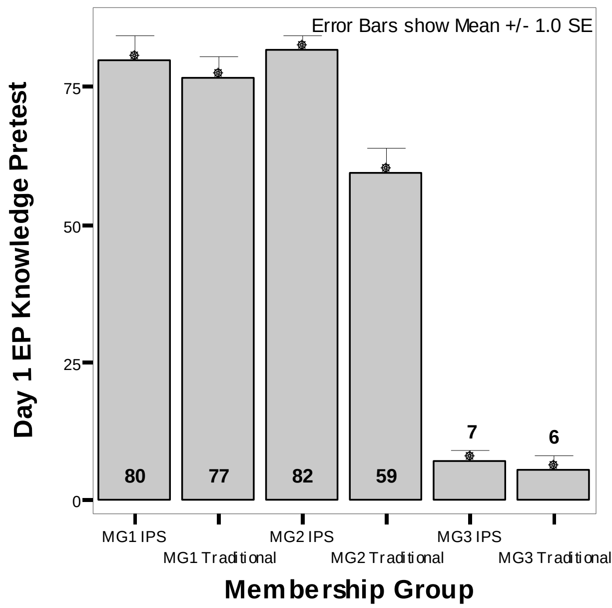


Figure O-1. Day 1 EP Knowledge Pretest means.

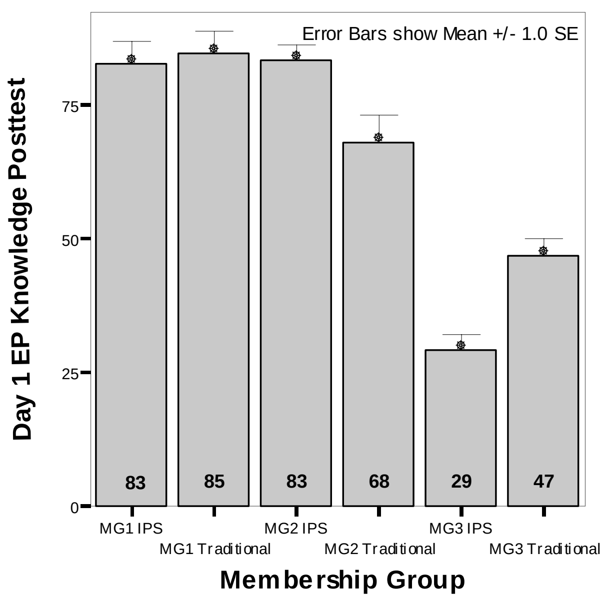


Figure O-2. Day 1 EP Knowledge Posttest means.

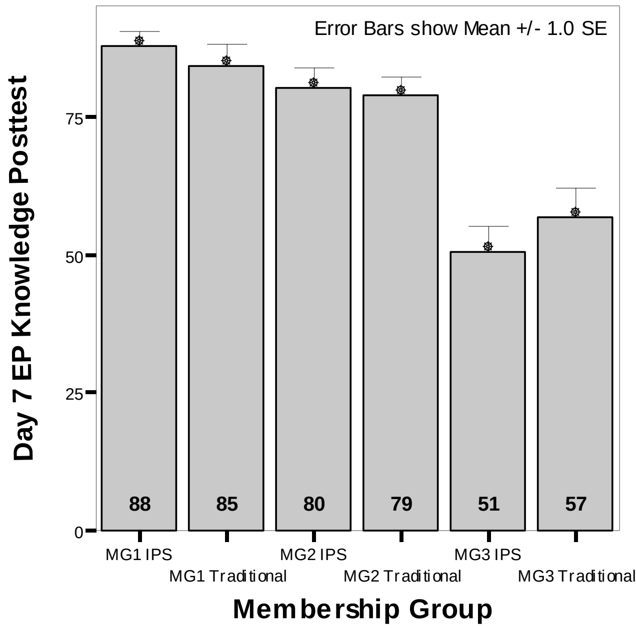


Figure O-3. Day 7 EP Knowledge Posttest means.

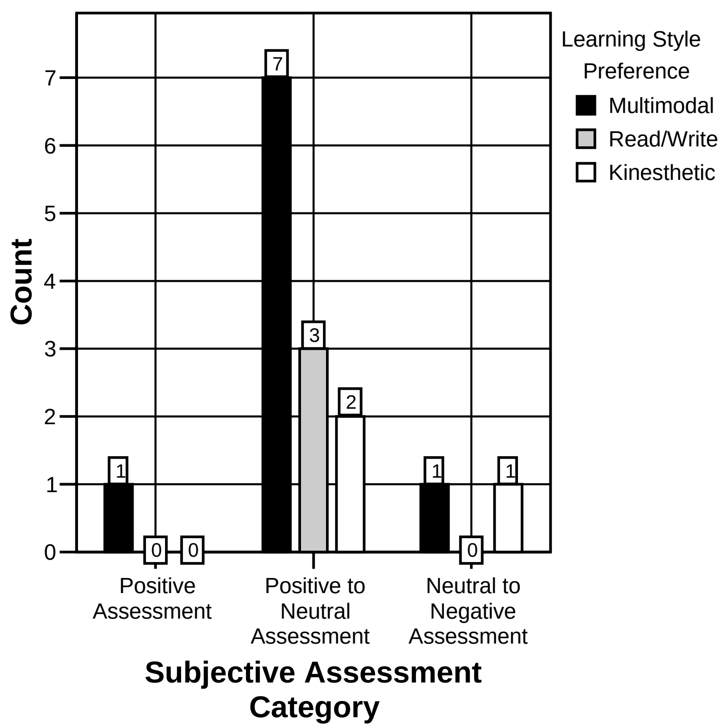


Figure O-4. MG 1 Learning Style Preference by IPS Subjective Assessment.

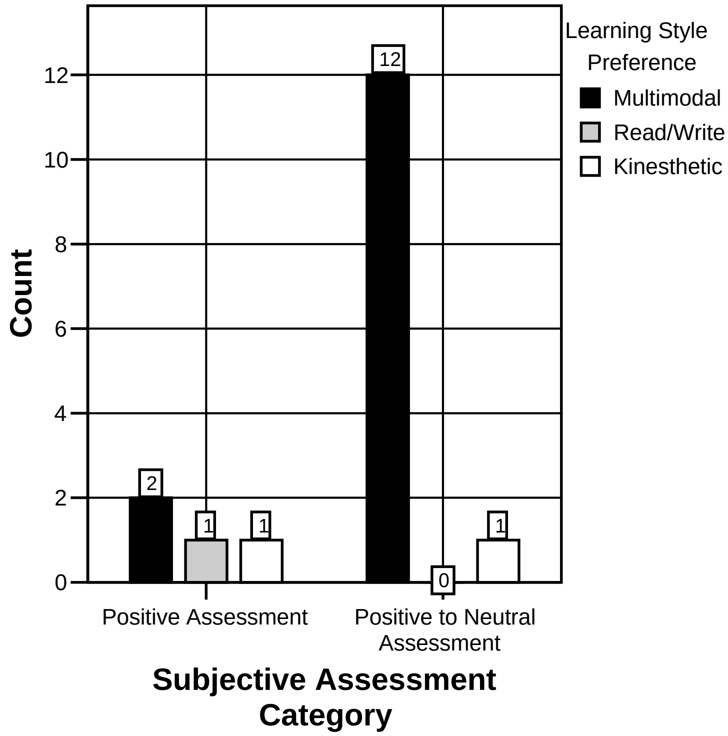


Figure O-5. MG 2 Learning Style Preference by IPS Subjective Assessment.

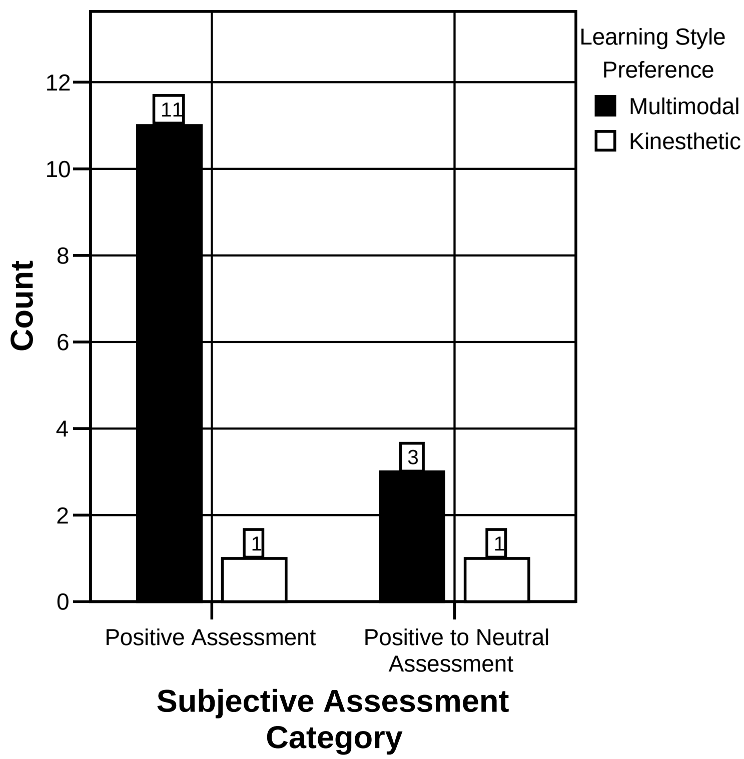


Figure O-6. MG 3 Learning Style Preference by IPS Subjective Assessment.

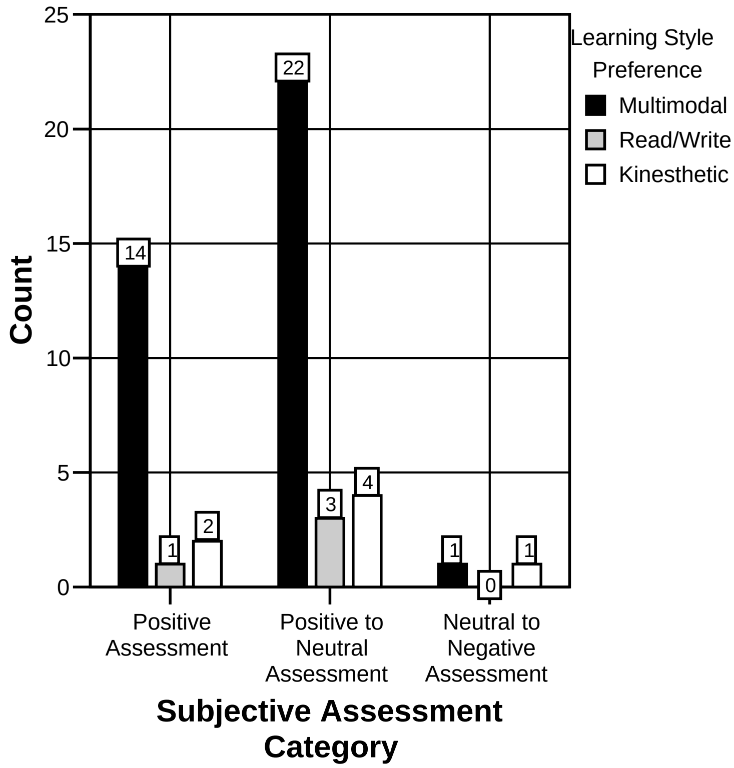


Figure O-7. MG Aggregate Learning Style Preference by IPS Subjective Assessment.

Appendix P.

Subjective Assessment Survey comments.

1. The symbols were very intuitive and would be much easier to identify in an emergency situation than the traditional numbered steps. Reading takes more time than looking at a single symbol which represents multiple words.
2. For engine power control lever to resemble actual: [Subject drew in alternative symbol.]
3. I think the system has really great potential. I think the pictures definitely allowed me the ability to memorize the verbiage a lot easier than just memorizing the words. I didn't study as much as I would have liked to and I think that if I would I would have been successful with the tests. I look forward to using this type of studying to help me later on in flight school. Thanks for developing and giving us this resource. Sorry, one more thought…I was wondering if there is a way to incorporate all steps of the EP into one picture so all you have to look at is one image. Just a thought. Thanks again!
4. I think IPS is great. I would adjust location of symbols. Engine compressor stall looks complex at first. The way I would do: [Subject drew alternative symbols above EP steps for compressor stall.] I think the IPS would cut down on reaction time in dealing with an emergency.
5. [The symbols for] Quadrant Failure / Loss to tail rotor thrust may be hard to find quickly if using symbols in cockpit might get blurred. (But I have never been in one yet, so unsure.)
6. I really liked the system. With all systems (learning) the most benefit is gleaned when it is adapted to the individual. In my studies I incorporated flash cards and leaned heavily on my aircraft mechanic to memorize the material. I felt when I adapted the symbols with my other study methods, my retention quickened greatly.
7. I have used and memorized emergency checklists in the past and I often have to memorize the checklist by taking mental pictures of the way the text appeared in the checklist. I believe that the IPS made memorizing these procedures very easy and less confusing than trying to memorize text. In fact I didn't even need to study the text to learn the procedures after I quickly learned what the pictures meant. I would not change anything and I not only recommend but hope that this or a similar method of checklist memorization is implemented. I believe that [the] IPS would free up my mental energy in an emergency situation as opposed to having to rely on text.
8. Personally, I found that the symbols made it easier to recall the proper procedure to perform in my mind when looking at it on paper vs. reading text.
9. I think for the fuel and engine control diagrams a letter could be used to annotate position instead of positioning the diagram differently [Subject drew in alternative symbols]. Overall, for myself the picture reference helped me a lot. I only studied once or twice for about an hour [and one-half] only paying half attention, but it stuck fairly well.
10. I had trouble at first distinguishing between engine fuel and fuel boost pump. [T]hose are the only symbols I had to learn. The fuel off looks backwards to the other fuel positions.
11. I don't feel that IPS helped recall the procedures in order. It did help significantly as far as quickly identifying the necessary procedures. Possibly putting the procedures (icons) from left to right might make remembering the order a little easier.
12. The system really helped me. I only wish I made more time for myself to study. If I had made more time for myself, this system would be great, easy to learn from.

13. As an instructor, it is evident some students have difficulty memorizing text procedures. Using visual symbols/aids for memorizing theses procedures I think would greatly benefit visual learners. To limit ourselves to one style of teaching restricts our effectiveness and ultimately reduces the effectiveness of crewmembers who could benefit from this technique. After the short class on the visual procedures, their meanings and the EP's themselves, the dual engine failure EP came up and I immediately saw [it] in my mind [Subject drew in the IPS symbol.]

14. Good system for new aviators. A little difficult for those [who] have already learned the EP.

15. The IPS did not assist me because I already had them memorized. It did help me recall specific procedures (meaning associating a picture for the EP). [T]he individual steps helped me organize what I already knew better; i.e., it didn't help me to associate pictures with every step in an EP, but it did help me recall the steps from memory faster when I saw the picture associated with the EP.

16. In terms of questions 13 and 14, using the IPS checklist alone during an actual EP, I feel, may induce more of a hazard. What should happen if, in the event of an EP during the confusion in the cockpit at the time a pilot would misinterpret a symbol; he or she might induce more of a hazard than the actual EP itself. Now, used in conjunction with the worded text or used as a study tool, I believe, would be a great success (i.e., the missed approach procedures in the approach plates have pictures as well as words.) In the heat of the moment, pictures work better, but the words accompanying work well, too!

17. I studied for a grand total of 15 min and only got a little confused with PCL and fuel system selectors.

18. Some of the symbols should be refined to be more easily identified by aviators. The actual symbol set for the EP should be more structured before being implemented.

19. If I would have spent more time studying this could be worthwhile. I would like to see an EP in checklist form to further my opinion.

20. It took me awhile to figure the PCL and Fuel system selector. [I] did not associate the symbol to the item at first.

21. I don't believe that the initial intuitiveness of the symbols has much bearing on the value of this concept. Once learned the symbols become intuitive (i.e., checklist symbols). I do believe that this is a much more simple [and] easy way to learn [and] recall the emergency procedures. I have to think of all the words in an EP [and] that takes time. To think of or see a couple symbols as a reference is much easier and conveys more with less. It also aids in correlation of actions to events. I would like to see this (or something similar) adopted into training. It seems like it would have value in the air; [flying] with "glass cockpits" as well.

22. With many hours and years of experience, I found IPS to be an excellent addition to my learning/retention. I strongly support continued study and integration into official flight training syllabus. We must continue forward with this promising program.

23. Great idea, however the symbols could be improved by using more detailed pictures instead of the [subject drew in stick figures].

24. This system could be useful if started early in the flight school program and reinforced throughout. Perhaps some type of informed daily questions concerning the symbols as a part of student flight briefing would offer good reinforcement.

25. Interesting concept. The symbols used probably need to be revised.

26. Some of the symbols, i.e., external stores and compressor stall are difficult to conceptualize and commit to memory.

27. Use the color red for all the [land as soon as possible and] autorotate.
28. Seems to be a much easier system to learn than having to learn the whole sentence.
29. [The] symbol for fuel system selector (the bend) should stay consistent for all three positions. On a malfunction display, symbols merely add a step which requires more interpretation and therefore, more time to process and a greater risk of error. If an MFD is capable of assisting in an emergency, why not simply display the text? We're only taling about underlined steps here.
30. Some symbols weren’t intuitive (as demonstrated by symbols posttest), but overall a useful system.
31. Establish single-engine airspeed symbol is not intuitive.
32. Fuel system selector position was not intuitive (cross feed, direct, off). High speed shaft failure [was] not intuitive. [The] IPS system seems like it would be an additional step to memorize. Aviators would still need to memorize written steps, and the IPS would add confusion.